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Major P. A. MACMAHON, D.Sc., Sc.D., LL.D., F.R.S., PRESIDENT, in the Chair.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Rev. F. C. Lees, M.A., F.R.G.S., 45 Cavendish Road, Sutton, Surrey (proposed by Theodore E. R. Phillips);

Hector Munro Macdonald, M.A., F.R.S., Professor of Mathematics, University, Aberdeen (proposed by P. A. MacMahon);

William John Roberts, Tullyroan, Co. Armagh (proposed by W. Redfern Kelly); and

Captain the Hon. Victor A. Spencer, 50A Curzon Street, London, W1 (proposed by J. W. Nicholson).

Forty presents were announced as having been received since the last Meeting, including, amongst others:—

Astrographic Catalogue, 1900·0; Hyderabad Section, Dec. − 16° to − 21°, vol. i., Dec. − 17°, presented by the Nizamiah Observatory.

The Variation of Latitude. By Sir F. W. Dyson, F.R.S.
(Plate 2.)

1. The movement of the pole of rotation round the pole of figure of the Earth consists of a fourteen-monthly combined with an annual term. The long series of observations of the International Latitude Service makes it possible to re-examine various questions considered by Chandler and other astronomers. The object of this paper is (1) to determine the mean length of the free period; (2) to examine whether it is circular; (3) to find to what extent the amplitude and phase are variable; (4) to examine the circularity and constancy of the annual term.

The international series of observations began in 1900. The six participating observatories are situated in latitude 39°, and do not differ by more than a few seconds. In longitude they are distributed as follows:—

Mizusawa in Japan	$\lambda = 141^\circ$
Tschardjui in Central Asia	$\lambda = -63^\circ$
Carloforte in Sardinia	$\lambda = -8^\circ$
Gaithersburg in U.S.A.	$\lambda = +77^\circ$
Cincinnati in U.S.A.	$\lambda = +84^\circ$
Ukiah in U.S.A.	$\lambda = +123^\circ$

Other observations such as those at Pulkovo and Greenwich, made in this period, have only been referred to incidentally, the discussion being mainly confined to the analysis of the results of these six stations.

In the decade before 1900 observations were made in a large number of observatories in many parts of the world. Before 1890 the most valuable observations are those made with the vertical circle and prime vertical instrument at Pulkovo at different times since 1840. Other observations are those made at Washington, 1862–67; Leyden, 1864–69; and Greenwich, 1836–50 and 1825–36.

These series of early observations and many others were discussed by Chandler. Only those here referred to are considered in this paper. The other series discussed by Chandler are not of sufficient accuracy to be of much value at the present time. This was probably Chandler's opinion, as they are not used in his later work.

The observations are considered in the reverse of their chronological order. §§ 2–7 deal with the observations since 1900, particularly the international series from 1900·0 to 1912·0, using the figures given by Przybyllok in *A.N.* 4840–41. After a brief account of the method of reduction of the international series in § 2, the "Kimura" term is considered in § 3, in order to show to what extent a variation of latitude may be due to other causes than the movement of the pole. The values of x and y—the co-ordinates of the instantaneous pole of rotation—are analysed in § 4 for the annual term and in § 5 for the free period. The six observatories are then considered separately, and the annual period considered in § 6 and the free period in § 7. The observations before 1900 are dealt with in more summary fashion. In

§ 8 the annual terms in x and y are considered for the period 1890–1900. The free periods are considered in § 9, and the times of successive minima and the amplitudes of each free oscillation from 1882 to 1917 are collected. In § 10 the epochs of minima of the free period from 1825 to 1882 are collected. The length of the free period is determined in § 11, and a summary of the conclusions of the paper given in § 12.

2. The observations made at the observatories co-operating in the International Latitude Service have been reduced at Potsdam under the direction of Albrecht and Wanach, and the results published at intervals in five volumes of *Resultate des Internationalen Breitendienst*, provisional results having been published annually in the *Astronomische Nachrichten*.

The observatories used the same stars, which were divided into twelve groups. Two groups were observed on each night, I. and II. for a period, then II. and III., and so on, the cycle of the year concluding with XII. and I. The latitude was obtained separately for each period, the groups of stars being connected by the differences I.–II., II.–III., etc., found during each period. The main difficulty in the reduction of the observations was found in the persistent character of the closing error or sum of these quantities which, instead of being zero, came out consistently for all the observatories as $-0''{\cdot}20$. This error was distributed equally among the different groups. A smooth curve was then drawn through the observed latitudes for each of the twelve periods, and from it the variation of latitude derived for each tenth of the year, 1900·0, 1900·1, etc.

Denoting by x and y the co-ordinates of the instantaneous pole, and adding an empirical unknown quantity z, there are for each tenth of the year six equations of the form $x\cos\lambda + y\sin\lambda + z = \Delta\phi$, where λ is the longitude of any of the six stations and $\Delta\phi$ the observed variation of latitude. In this way x, y, z are determined for each epoch.

3. The z term, whose existence was discovered by Kimura, has been discussed by him (*A.N.*, 3783, 4344), by Ross (*A.N.*, 4593), Przybyllok (*A.N.*, 4840–41), Wanach (*A.N.*, 4858). The subject is reviewed, and the possible causes which may give rise to this term are considered by Jones in *Observatory*, 1916, pp. 95–103.

Its general character will be seen from the table in § 4. For the years 1900–1912 it is in the mean $''{\cdot}005 + ''{\cdot}053\cos(\theta + 30^\circ)$ where $\theta = 360^\circ \times t$, and t is the fraction of the years. Since 1912 the constant term has largely increased. The origin of this term is probably to be sought along with that of the closing error referred to in § 2, as a different distribution of this error would alter the term. The closing error indicates a tendency of the apparent zenith to shift during the course of a night's observations, and is generally attributed to meteorological causes producing a zenithal refraction varying in the course of the night and at different seasons.

Observations of δ Cassiopeiæ at Pulkovo (*A.N.*, 4858) give better agreement with the international results when z is omitted.

The difference between $x+z$ and the Greenwich results are (unit $=''\cdot01$)—

	·0.	·1.	·2.	·3.	·4.	·5.	·6.	·7.	·8.	·9.
1912	+18	+12	+ 9	+ 9	+ 6	+ 7	+ 8	+ 7	+ 7	+ 6
1913	+ 6	+ 6	+ 5	+ 3	+ 4	+12	+14	+10	+12	+15
1914	+15	+15	+17	+17	+12	+ 7	+ 9	+10	+12	+12
1915	+ 4	+ 5	+11	+11	+ 6	+ 3	+ 5	+ 5	+ 7	+10
1916	+12	+14	+13	+ 8	+ 5	+ 5	+ 8	+10	+ 9	+12

while the differences between x and the Greenwich results are—

1912	+12	+ 6	+ 7	+10	+ 9	+ 7	+ 5	+ 3	+ 3	+ 3
1913	+ 3	+ 2	+ 2	+ 3	0	+12	+11	+ 5	+ 5	+ 7
1914	+ 6	+ 5	+ 6	+11	+11	+ 5	+ 2	0	+ 1	+ 1
1915	− 2	0	+ 5	+ 5	+ 7	+ 3	0	− 1	+ 2	+ 3
1916	+ 4	+ 6	+ 5	+ 5	+ 6	+ 5	+ 5	+ 4	+ 1	+ 4

Excluding the z term, the difference between the variation of latitude found from the international results and at Greenwich is

$$+''\cdot042-''\cdot017\cos(\theta+50^\circ).$$

When the z term is included, it is

$$+''\cdot093+''\cdot019\cos\theta.$$

Thus a large constant difference is introduced by the inclusion of the z term. The periodic term of the difference is of the same amplitude but different phase as the z term is or is not included. Further, the mean discordance—a constant being taken out—is $\pm''\cdot026$ without the z term and $\pm''\cdot032$ with the z term. Thus agreement is somewhat better without the z term.

As the observatories at Carloforte and Greenwich differ only 8° in longitude, a direct comparison of the variation of latitude at the two places is possible. For 1912–1916

$$\text{Carloforte}-\text{Greenwich}=+''\cdot058+''\cdot024\cos(\theta+5).$$

This brief reference to the "Kimura" term is somewhat apart from the main purpose of this paper; it is introduced to show the extent to which the observed variation of latitude may be due to other causes than movement of the pole, particularly as regards annual terms.

4. A preliminary examination of the observations from 1890 to 1917 showed that the period was somewhat longer than 428 days given by Chandler, and nearer 432 days. Thus six periods take place in 7·10 years and five in 5·92 years. The annual period is thus obtainable nearly from the mean of six or of seven consecutive years. Beginning with the results for the years 1900·0–1912·0 given in *A.N.*, 4840–41, and interpolating so as to obtain values for the epochs ·05, ·15, etc., and keeping the figures to the nearest $''\cdot01$, we find the following values of x, y, z for each tenth of a year from 1900·0 to 1912·0.

Value of x, y, z interpolated from A.N., 4841 (Unit ″·01).

	·05.	·15.	·25.	·35.	·45.	·55.	·65.	·75.	·85.	·95.
					x.					
1900	+ 6	+ 5	+ 1	− 1	− 4	− 5	− 6	− 6	− 7	− 2
01	0	+ 4	+ 7	+11	+13	+10	+ 6	+ 1	− 6	− 9
02	−10	− 6	− 1	+ 9	+16	+21	+17	+ 9	0	−10
03	−15	−16	−10	− 2	+ 8	+15	+21	+19	+12	+ 2
04	−10	−16	−17	−12	− 4	+ 5	+12	+17	+15	+12
05	+ 2	− 8	−12	−14	−10	− 4	+ 5	+10	+12	+14
06	+ 5	− 1	− 5	−10	−11	−10	− 6	− 2	+ 2	+ 4
07	+ 6	+ 5	+ 6	+ 5	+ 1	− 1	− 5	−12	−13	− 8
08	− 3	+ 7	+14	+21	+22	+18	+ 9	− 4	−15	−24
09	−28	−20	− 8	+ 9	+24	+32	+30	+20	+ 2	−13
10	−21	−28	−28	−16	+ 2	+19	+29	+31	+25	+12
11	− 4	−17	−24	−19	−14	0	+12	+21	+27	+27
					y.					
1900	+ 1	− 2	− 6	− 6	− 8	− 7	− 4	+ 1	+ 2	+ 3
01	+ 7	+ 5	+ 4	− 1	− 6	−13	−14	−11	−10	− 5
02	+ 5	+11	+17	+18	+14	+ 6	− 2	− 9	−11	− 9
03	− 2	+ 8	+14	+22	+23	+19	+11	− 1	−11	−14
04	−11	− 5	+ 5	+15	+20	+19	+15	+ 8	+ 2	− 6
05	−14	−13	−10	0	+ 8	+16	+18	+17	+10	+ 2
06	− 4	− 5	− 3	0	+ 5	+ 9	+12	+13	+13	+14
07	+ 8	+ 3	− 1	− 4	− 6	− 7	− 5	+ 1	+ 9	+16
08	+21	+21	+18	+ 7	− 2	−11	−16	−17	−13	− 4
09	+ 8	+21	+30	+31	+24	+ 9	− 7	−19	−25	−26
10	−19	0	+14	+29	+35	+34	+21	0	−16	−27
11	−28	−19	− 4	+12	+27	+33	+31	+23	+ 8	− 5
					z.					
1900	+ 2	0	− 2	− 4	− 4	− 2	− 3	0	+ 4	+ 8
01	+ 7	+ 4	− 1	− 2	− 3	− 3	− 1	0	+ 2	+ 4
02	− 1	+ 1	− 2	− 5	− 6	− 4	− 2	+ 1	+ 3	+ 4
03	+ 4	+ 3	+ 2	− 1	− 3	− 2	0	+ 3	+ 5	+ 6
04	+ 5	+ 4	0	− 2	− 2	0	+ 2	+ 3	+ 5	+ 6
05	+ 3	+ 2	− 2	− 4	− 7	− 3	− 2	+ 1	+ 2	+ 3
06	+ 1	− 3	− 7	− 7	− 6	− 5	− 2	+ 1	+ 4	+ 4
07	− 2	− 3	− 5	− 7	− 6	− 4	0	+ 2	+ 3	+ 1
08	− 1	0	+ 1	− 5	− 4	− 2	+ 2	+ 5	+ 6	+ 6
09	+ 5	+ 2	+ 2	− 4	− 5	− 2	+ 2	+ 4	+ 6	+ 7
10	+ 5	+ 4	+ 3	− 2	− 4	− 2	+ 1	+ 5	+ 6	+ 8
11	+ 9	+ 7	+ 8	0	− 3	− 3	+ 1	+ 3	+ 7	+12

By taking means for any consecutive six or seven years, a mean value of the annual period is found for each epoch. There is not a large range in these values. For example,

$$x = +″·076 \cos(\theta + 118°) \text{ for } 1900–1905$$
$$x = +″·102 \cos(\theta + 124°) \text{ for } 1906–1911$$

and

$$y = -″·064 \sin(\theta + 110°) \text{ for } 1900–1905$$
$$x = -″·093 \sin(\theta + 115°) \text{ for } 1906–1911$$

where $\theta = 360°·t$, t being the fraction of the year.

For the whole period 1900·0–1912·0

$$x = +''\cdot089\cos(\theta + 118^\circ)$$
$$y = -''\cdot079\sin(\theta + 115^\circ).$$

The agreement in amplitude and phase shows the annual term to be nearly circular. The mean for 1900·0–1912·0 is actually an ellipse with major axis ″·089 in a direction 4° west of Greenwich, and minor axis ″·072. The instantaneous pole is near the end of the major axis about September 1.

There appears to be a small change in the annual component, which is larger in the years 1906–1912. But, speaking generally, the annual component of the movement of the pole between 1900·0 and 1912·0 was a circle of radius ″·084.

The value of z is

$$+''\cdot047\cos(\theta + 30^\circ) \text{ for } 1900\text{–}1905$$
$$+''\cdot060\cos(\theta + 30^\circ) \text{ for } 1906\text{–}1911.$$

5. *The Free Period.*—When the annual term has been taken out of the figures in Table I., the successive free periods are shown more distinctly. When plotted, the most remarkable feature shown is a large increase of amplitude during the later cycles. The following table, which gives the amount of successive maxima in x and y from 1900 to 1912, shows this clearly :—

x.		y.	
Max.	Min.	Min.	Max.
″	″	″	″
+·14	−·16	−·17	+·07
+·14	−·11	−·19	+·08
+·14	−·12	−·09	+·12
+·11	−·11	−·10	+·11
+·11	−·16	−·16	+·17
+·14	−·18	−·11	+·19
+·14	−·20	−·18	+·23
+·23	−·23	−·22	+·23
+·23	−·22	−·21	+·25
+·22	−·22	−·26	+·26

Analysis of the figures for x and y for the periods 1900·0–1906·0 and 1906·0–1912·0 give

$$1900\cdot0\text{–}1906\cdot0\ x = +''\cdot127\cos\frac{2\pi}{T}(t - 1902\cdot47)$$

$$y = +''\cdot131\cos\frac{2\pi}{T}(t = 1902\cdot20)$$

$$1906\cdot0\text{–}1912\cdot0\ x = +''\cdot206\cos\frac{2\pi}{T}(t - 1909\cdot55)$$

$$y = +''\cdot213\cos\frac{2\pi}{T}(t - 1909\cdot25)$$

In both cases the amplitudes agree closely, and the times of maxima differ very nearly by a quarter period. During each of these intervals the mean free movement of the pole was circular, but of amplitudes ″·26 and ″·42 respectively.

6. The results for the six observatories given in *A.N.*, 4841, were next examined separately. The mean annual terms for the interval 1900·0–1912·0 are:

Mizusawa	$\lambda = -141^\circ$	$+ ″·109 \cos\theta + ″·014 \sin\theta$
Tschardjui	$\lambda = -63^\circ$	$+ ·077 \cos\theta - ·061 \sin\theta$
Carloforte	$\lambda = -8^\circ$	$+ ·001 \cos\theta - ·097 \sin\theta$
Gaithersburg	$\lambda = +77^\circ$	$- ·048 \cos\theta + ·014 \sin\theta$
Cincinnati	$\lambda = +84^\circ$	$- ·050 \cos\theta + ·004 \sin\theta$
Ukiah	$\lambda = +123^\circ$	$+ ·006 \cos\theta + ·061 \sin\theta$

It may be noticed that Tschardjui and Ukiah are nearly 180° apart in longitude, and if these terms represented a movement of the pole, they should be of nearly equal amount and opposite sign. An agreement is brought about by taking out the Kimura term. The amount of this is $+ ″·041 \cos\theta - ″·011 \sin\theta$. Thus the annual part of the polar movement shown at the different observatories is

Mizusawa	$+ ″·068 \cos\theta + ″·025 \sin\theta = ″·072 \cos(\theta + \lambda + 129^\circ)$
Tschardjui	$+ ·036 \cos\theta - ·050 \sin\theta = ·062 \cos(\theta + \lambda + 119)$
Carloforte	$- ·040 \cos\theta - ·086 \sin\theta = ·095 \cos(\theta + \lambda + 123)$
Gaithersburg	$- ·089 \cos\theta + ·003 \sin\theta = ·089 \cos(\theta + \lambda + 101)$
Cincinnati	$- ·091 \cos\theta - ·007 \sin\theta = ·091 \cos(\theta + \lambda + 101)$
Ukiah	$- ·035 \cos\theta + ·050 \sin\theta = ·062 \cos(\theta + \lambda + 141)$

The annual terms at the three observatories Mizusawa, Carloforte, and Ukiah obtained from means of six consecutive years are as follows:—

	Mizusawa.		Carloforte.		Ukiah.	
	$+ ″·026 \sin\theta$	$+ ″·103 \cos\theta$	$- ″·093 \sin\theta$	$+ ″·001 \cos\theta$	$+ ″·046 \sin\theta$	$+ ″·014 \cos\theta$
1900–05						
01–06	+ ·036	·107	- ·100	+ ·004	+ ·039	- ·007
02–07	+ ·034	·088	- ·097	+ ·010	+ ·015	- ·009
03–08	+ ·013	·065	- ·068	+ ·008	+ ·007	+ ·014
04–09	- ·009	·082	- ·072	- ·012	+ ·029	+ ·033
05–10	- ·001	·105	- ·091	- ·021	+ ·067	+ ·024
06–11	- ·025	·116	- ·102	- ·019	+ ·078	+ ·008
07–12	+ ·033	·110	- ·097	- ·011	+ ·067	+ ·002
08–13	+ ·029	·114	- ·091	- ·013	+ ·066	+ ·008
09–14	+ ·037	·124	- ·099	- ·008	+ ·068	0
10–15	+ ·042	·111	- ·093	0	+ ·067	- ·014
11–16	+ ·026	·103	- ·093	+ ·003	+ ·061	- ·006

These are made up of the annual part of the polar movement and of the z term. It seems reasonable to suppose that a part of the variations they show are attributable to the latter.

7. In the discussion of the free period as shown by the different observatories the annual terms given at the beginning of § 6 were extracted, and the figures then plotted. This is a rather complicated diagram to reproduce, and only the three observatories at Carloforte, Mizusawa, and Ukiah are given.

The agreement of the observatories is seen also in the following table, where the observed epochs of maxima and minima are given in the first six columns and the range in the last six. To make the epochs readily comparable, allowance has been made for the differences of longitude by applying $-\cdot47$, $-\cdot21$, $-\cdot03$, $+\cdot26$, $+\cdot28$, $+\cdot41$ to the observed times at Mizusawa, Tschardjui, etc.

Epochs of Maxima and Minima.						Amplitudes.					
Miz.	Tsch.	Carl.	Gait.	Cin.	Uk.	Miz.	Tsch.	Carl.	Gait.	Cin.	Uk.
00·04	·15	·12				23	24	32			
00·68	·69	·64	·73	·76	·73	19	27	35	26	33	31
01·15	·29	·23	·25	·28	·26	28	29	25	33	41	33
01·91	·91	·92	·88	·91	·91	29	19	19	33	43	24
02·34	·52	·50	·47	·53	·50	27	17	24	21	28	21
03·10	·19	·07	·02	·04	·08	29	26	24	22	30	23
03·70	·67	·71	·65	·64	·58	27	33	21	22	24	16
04·32	·23	·24	·36	·18	·20	25	29	23	16	19	22
04·84	·84	·87	·91	·88	·92	29	35	29	27	36	26
05·38	·49	·45	·53	·53	·50	34	22	32	37	35	28
06·00	·04	·97	·05	·03	·04	35	19	30	28	23	28
06·56	·61	·54	·58	·51	·54	38	34	29	30	32	31
07·15	·21	·17	·15	·16	·17	42	38	33	33	36	33
07·69	·76	·79	·73	·73	·75	46	49	44	36	33	36
08·33	·36	·32	·33	·38	·34	52	43	52	39	31	44
08·95	·99	·97	·93	·90	·92	52	40	49	44	36	51
09·54	·53	·59	·45	·55	·57	50	41	42	49	58	48
10·16	·16	·18	·14	·24	·15	49	47	41	49	46	50
10·74	·79	·73	·74	·73	·74	59	48	39	54	37	55
11·37	·39	·41	·27	·28	·29	51	46	41	54	42	53
11·94	·91	·95	·82	·88	·95	42	47	45	46	33	48
12·50	·63	·57	·55	·53	·55	38	40	44	42	39	46
13·20	·23	·19	·16	·11	·16	28	23	39	39	31	49
13·78	·79	·79	·74	·78	·77	35	35	37	34	42	46
14·31	·45	·31	·32	·43	·40	37		37	25	43	31
14·95		·97	·91	·97	·89	35		34		56	41
15·59		·56		·56	·66	32		36			46
16·07		·18			·20						39
16·		·74			·70						44
17·					·24						

The table given above shows that the amplitude of the free period is the same in all longitudes, *i.e.* that the movement of the pole is circular, but that there is a variation in its amplitude. From 1902 to 1904 the semi-amplitude was only ″·12, while from 1908 to 1912 it was greater than ″·20 and reached ″·24. It should, however, be noticed that the z or Kimura term was large and irregular during this period (*A.N.*, 4841).

8. During the decade 1890–1900 many series of accurate determinations of variation of latitude were made at observatories situated in different parts of the world. Some of these are only short series, but taken together they were sufficient for Albrecht to determine the co-ordinates of the pole for each tenth of a year from 1890·0 to 1900·0, on the assumption that the variation of latitude was entirely due to a movement of the pole. Thus x and y being the co-ordinates of the instantaneous pole, the variation of latitude observed at a place in longitude λ was equated to $x\cos\lambda + y\sin\lambda$, and there was sufficient material to determine x and y. From Albrecht's figures the annual term is found to be

$$+″·092\cos(\theta + 90^\circ) \text{ in } x$$

and

$$-″·052\sin(\theta + 116^\circ) \text{ in } y.$$

If it were certain that the variation of latitude at each observatory was entirely due to movement of the pole, these would indicate that the annual term of the polar movement was elliptic. In his paper in *A.N.*, 4344, Kimura has for the period 1891·5–1900·0 been able, in spite of somewhat unfavourable distribution of the observatories, to include a determination of the z term, and make a solution for latitude variation by the equation $x\cos\lambda + y\sin\lambda + z$. For the period 1893·8–1899·8 he finds for the annual period

$$x = +″·011\sin\odot - ″·096\cos\odot + ″·005$$
$$y = + \cdot 051\sin\odot + \cdot 004\cos\odot + \cdot 008.$$

The annual term remains elliptic. Nevertheless it should be remarked that the better series of observations begun in 1900 give a movement much more circular in character. As Kimura points out, the observatories giving the x term are much more northerly than those of the international series.

9. The annual terms were taken out of the values of x and y, and the free oscillation plotted for each co-ordinate. The epochs of minima are given below, that for y being corrected for a quarter period, and the mean of the two results taken. For the years 1882–1890, Nyrén's results (*Bull. Acad. S. Péter.*, 7), have been used. The annual period, as explained by Nyrén (*Bull. Acad. S. Péter.*, 7, 354), may have been largely taken out by the method of reduction; at any rate, only the small annual term $-″·017\sin(\theta + 3^\circ)$ remains. This has been taken out. The epochs have been put ·10 year earlier to make them applicable to the longitude of

Greenwich. In this way the following table of dates of minima and of amplitudes of the free period have been obtained.

Amplitudes and Epochs of Minima of Free Period of Latitude Variation.

Ampl. Obs.	Epoch of Minimum.			Ampl. Obs.	Epoch of Minimum.		
	Obs.	Calc.	O − C.		Obs.	Calc.	O − C.
″				″			
0·35	1882·87	82·97	− ·10	0·27	1900·71	1900·72	− ·01
·30	84·18	84·15	+ ·03	·30	01·91	01·90	+ ·01
·36	85·20	85·33	− ·13	·24	03·09	03·08	+ ·01
·32	86·50	86·52	− ·02	·23	04·35	04·27	+ ·08
·31	87·75	87·70	+ ·05	·30	05·48	05·45	+ ·03
·39	89·00	88·88	+ ·12	·30	06·56	06·63	− ·07
·44	90·05	90·07	− ·02	·38	07·74	07·82	− ·08
·38	91·20	91·25	− ·05	·44	08·96	09·00	− ·04
·32	92·36	92·43	− ·07	·48	10·17	10·18	− ·01
·31	93·54	93·62	− ·08	·48	11·34	11·37	− ·03
·28	94·72	94·80	− ·08	·42	12·56	12·55	+ ·01
·28	95·88	95·98	− ·10	·37	13·77	13·73	+ ·04
·30	97·14	97·17	− ·03	·39	14·94	14·92	+ ·02
·26	98·34	98·35	− ·01	·37	16·15	16·10	+ ·05
·30	99·56	99·53	+ ·03	·38	17·28	17·28	·00

A part of these irregularities in amplitude and in the intervals between successive minima are of an accidental character. But the very large amplitudes about 1910 are found in the six co-operating observatories, as was shown in a previous paragraph. Similarly, the small values from 1900 to 1904 are shown fairly consistently by six observatories. The small amplitudes found from 1892 to 1900 are shown in both x and y. The free movement of the pole appears from about 1893 to 1906 to have had an amplitude of less than 0″·30, while during the last ten years it has been over ″·38, reaching a maximum of ″·48 about 1910. Kimura, who has treated the matter very similarly in *A.N.*, 4344, notes that the fourteen-monthly term increased in period from 1890 to 1897 and then decreased to 1909—and also the large amplitude about 1890. These may be real changes, but they are not so marked as the large amplitude about 1910.

10. Previous to 1882 the most important series of observations are those made at Pulkovo. The meridian observations from 1864 to 1875 and 1842 to 1849 have been reduced by Ivanoff (*Bulletin de l'Académie Impériale des Sciences de St.-Pétersbourg*, 1893 Dec. and 1894 Sept.). In the series 1864–1875, a very different annual term is given by the first six and the second six years. It hardly seemed possible to take out an annual period and exhibit the free periods separately. The mean of the years

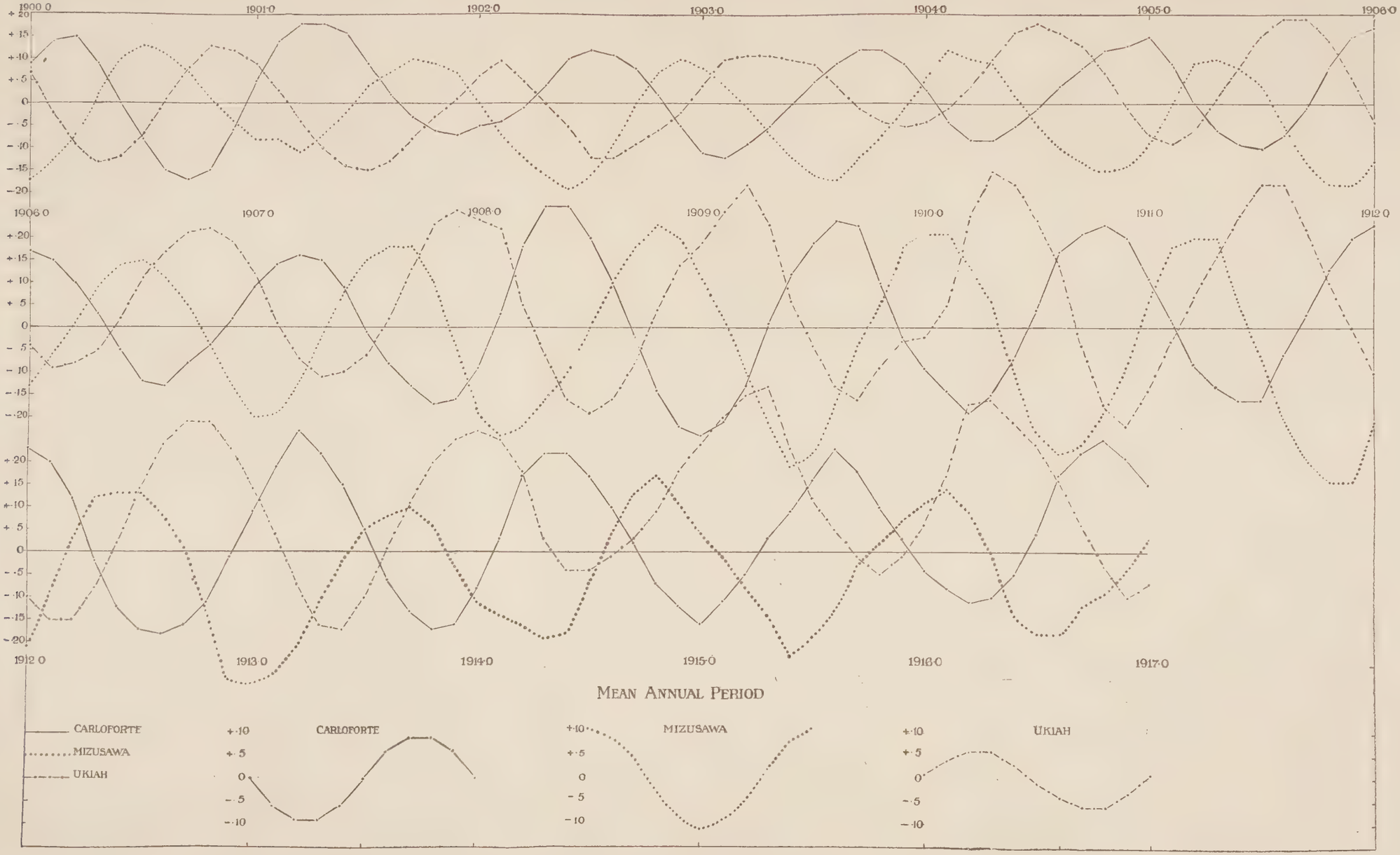

Diagram showing Variation of Latitude, 1900·0 to 1917·0, at Carloforte, Mizusawa, and Ukiah, after Annual Term has been extracted.

1864–1869 and 1870–1875 are therefore taken, and give for the oscillation for the longitude of Pulkovo

$$-''\cdot 186 \cos \frac{2\pi}{T}(t - 1866\cdot 53)$$

and

$$-''\cdot 166 \cos \frac{2\pi}{T}(t - 1872\cdot 48).$$

Similarly, the observations from 1842–1849 give

$$-''\cdot 104 \cos \frac{2\pi}{T}(t - 1845\cdot 17).$$

These figures are in good accordance with the times of minima given by Ivanoff.

11. The remaining observations considered are given by Chandler, *A.J.*, 446, viz.:—

Pulkovo Prime Vertical, 1840–55 and 1875–82.
Leyden Meridian Circle, 1864–74.
Greenwich Mural Circle, 1825–36 and 1836–50.

The epochs of minima are taken from Chandler. I have added to these the Washington observations 1862–1867 as discussed by Newcomb (*A.J.*, 251). The results of all these series of observations are collected in the following table, which gives the times of minima deduced from the different series as applying to the longitude of Greenwich:—

Observatory.	Instrument.	Date.	Epoch of Minimum.		
			Obs.	Cal.	O – C.
Greenwich	Mural Circle	1825–36	1830·18	29·72	+ ·46
,,	,,	1836–50	41·66	41·56	+ ·10
Pulkovo	Prime Vertical	1840–55	42·85	42·74	+ ·11
,,	Vertical Circle	1842–49	46·27	46·29	– ·02
,,	,,	1864–69	67·62	67·59	– ·03
Leyden	Meridian Circle	1864–74	67·58	67·59	– ·01
Washington	,,	1862–67	67·57	67·59	– ·02
Pulkovo	Vertical Circle	1870–75	72·38	72·32	+ ·06
,,	Prime Vertical	1875–82	78·28	78·24	+ ·04
,,	Vertical Circle	1882–88	85·30	85·34	– ·04
Many observatories		1889–93	91·23	91·25	– ·02
,, ,,		1894–99	97·13	97·17	– ·04
International series		1900–05	1903·11	03·08	+ ·03
,, ,,		1906–11	1908·95	09·00	– ·05
,, ,,		1911–17	1914·94	14·92	+ ·02

The mean of the international series gives a minimum at 1909·00. With this as starting-point and an assumed period of $6T = 7\cdot 10$ years or $T = 1\cdot 1833$ years, the figures in the fourth column are calculated. The agreement is excellent, except the series of observations by Pond. It seems to me that the epoch of minimum as given by these observations must be rejected.

The period of 1·1833 years or 432·2 days is considerably longer than that found by Chandler, which was 428 days. It would seem that any variability in the length of the period must be confined within narrow limits.

Summary.

12. (1) The mean free period is 432 days or 6T = 7·10 years.
(2) The free motion is circular, and shows changes in amplitude.
(3) The annual term is fairly constant, and probably represents a nearly circular motion, though there is some evidence of the amplitude being slightly smaller for longitude 90° than for the Greenwich meridian.

The Movements of the Earth's Pole. Note on Sir F. W. Dyson's Analysis. By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. In several papers communicated to the Royal Meteorological Society (*Quarterly Journal*, **41**, 315; **42**, 163; **43**, 43; see also April 1918) I have suggested that meteorological history is divisible into well-marked chapters of average length $6\frac{1}{3}$ years, though not of uniform length, the chief departure from uniformity recurring in a cycle of $6\frac{1}{2}$ chapters, or 41·2 years (**41**, 320, 321). The commencements of the chapters were connected provisionally with the movements of the Earth's Pole; and the object of the present note is to show how the discussion of these movements by the Astronomer Royal supports the view of association with the meteorological phenomena. At present I do not think it can be said which is cause and which is effect; but we can at least study the association.

2. A characteristic feature of the meteorological chapters is their alternation. Numbering them consecutively from an arbitrary zero, the "even" chapters differ systematically from the "odd." The nature of the difference is sometimes simple—there may be a different average temperature, for instance, or average rainfall, though even then that may not be the whole difference. The whole differences may ultimately be expressible in simple form, or traceable to simple causes, but at present their expression is complex. The hope of ultimate simplicity is, however, encouraged by the apparent existence of a simple difference in the movements of the Pole,—there seems to be a marked difference of *period* for the 14-monthly revolution.

3. Sir F. W. Dyson has arrived at an average period of 432 days for the 14-month term, fixing it as 6 revolutions in 7·10 years. Let us first deduce from these figures the period of "interference" between the 14-month and the 12-month term, which takes place when the former has completed exactly n turns and the latter $(n+1)$, so that

$$(n+1) : n = 7{\cdot}10 : 6,$$

giving $n = 5{\cdot}4545 \ldots (n+1) = 6{\cdot}4545 \ldots$; that is, the average period between "interferences," which should give the average length of a meteorological "chapter," is not 6·333 years as adopted (*Q. J.*, **41**, 320) but 6·455. The difference 0·122 year is larger than I expected, seeing that the meteorological data used go back to 1730, giving 27 chapters. To adopt Dyson's carefully determined value as it stands would introduce a total discrepancy of $27 \times {\cdot}122$ years $= 3{\cdot}3$ years, or half a chapter. The meteorological information for the eighteenth century is of course not so good as for the nineteenth, and it may be that the dates are wrong to this extent. That can only be determined by further investigation. Meanwhile we may remark that there is evidence of some long-period terms, especially one of 153 years, which may complicate the determination of a true average period.

4. But the important point is that Dyson's deviations from his average period show alternation in chapters, the alternating values being approximately 1·153 and 1·213 years, or 421 and 443 days instead of uniformly 432 days. The effect on the residuals of introducing such a supposition is shown in Table I., which has been constructed empirically so as to make the best possible fit of the residuals to a series of straight lines of equal and opposite slopes. Assuming that the period changes abruptly without change of immediate phase, the intersections of the lines give the dates of change as in Table II.

TABLE I.

Alternation of Dyson's Phase Residuals

(The unit is 0·01 year.)

F.W.D.	Corr.	R.	F.W.D.	Corr.	R.	F.W.D.	Corr.	R.
−10	+9	− 1	− 8	+9	+1	−8	+9	+1
+ 3	+6	+ 9	−10	+6	−4	−4	+6	+2
−13	+3	−10	− 3	+3	0	−1	+3	+2
− 2	0	− 2	− 1	0	−1	−3	0	−3
+ 5	−3	+ 2	+ 3	−3	0	+1	−3	−2
+12	−4	+ 8	− 1	−6	−7	+4	−6	−2
− 2	−1	− 3	+ 1	−5	−4	+2	−5	−3
− 5	+2	− 3	+ 1	−2	−1	+5	−2	+3
− 7	+5	− 2	+ 8	+1	+9	0	+1	+1
− 8	+8	0	+ 3	+4	+7			
			− 7	+7	0			

TABLE II.

Critical Dates.

From above intersections	1888·5	1894·4	1901·1	1907·6	1914·1
Q.J., 41, 320	1889·5	1895·3	1900·6	1906·3	1912·8
Q.J., 43, 48	1888·7	1895·1	1899·9		
Chapter	(113)	(114)	(115)	(116)	

The agreement between the dates formerly suggested and those now obtained is far from perfect, and the differences require consideration. But in the present state of our knowledge they do not suggest any fatal objection.

5. At the foot of the table are given the numbers of the chapters in the adopted arbitrary numeration; it will be seen that the residuals decrease (requiring increasing corrections) in the odd chapters; *i.e.* in the odd chapters the period is short (421 days) and in the even chapters it is long (443 days). In considering the 6-month period of Padua rainfall (which is the only case hitherto fully worked out of an alternation in *period* as opposed to amount) it was shown (*Q.J.* 41, 326 footnote) that the mean "slope" per 10 months or 600° for odd chapters gave an average residual −6°, and for even chapters +10°. The six-monthly period is thus shorter in the odd chapters in the ratio of 594° to 610°, or 1 to 1·027. The ratio of 421 days to 443 days is 1 to 1·052. These ratios may be associated; though it is as yet too early to assign a definite relationship.

6. Turning now to the coefficients of the 14-month term, they show no alternation, but they seem to be affected by the 41·2-year cycle (to which attention is drawn in the paper just quoted), and by its harmonics, especially the second harmonic. In 41·2 years there are about 34·8 periods of 1·183 years, and in the half cycle consequently about 17·4. The whole cycle is not completed within the series discussed (1882 to 1917) and can only be represented very speculatively; but the two sharp peaks of the half cycle are plainly visible in Table III. Some higher harmonics are included by taking for the half cycle a curve of special shape, with a sharp peak and a very flat valley; but this cannot include the third and fifth, which have coefficients of about 0″·01. They may, however, be neglected at the present stage.

TABLE III.

Dyson's Amplitudes (of the 14-Month Term) and the 40-Year Cycle.

(The unit is 0″·01; and 0″·34 has been subtracted.)

F.W.D.	(I.)	(II.)	R.	F.W.D.	(I.)	(II.)	R.	F.W.D.	(I.)	(II.)	R.
+ 1	−3	+ 3	+1	− 6	+4	+2	0	− 4	+2	+ 1	−1
· 4	−3	+ 2	−5	− 6	+5	+2	+1	+ 4	0	− 1	+3
+ 2	−2	+ 2	+2	− 4	+5	+3	+4	+10	−1	− 5	+4
− 2	−1	0	−3	− 8	+5	+3	0	+14	−2	−11	+1
− 3	0	− 2	−5	− 4	+5	+3	+4	+14	−3	−11	0
+ 5	+2	− 7	0	− 7	+5	+3	+1	+ 8	−4	− 5	−1
+10	+2	−12	0	− 4	+4	+3	+3	+ 3	−4	− 1	−2
+ 4	+3	− 7	0	−10	+4	+3	−3	+ 5	−5	+ 1	+1
− 2	+4	− 2	0	−11	+3	+3	−5	+ 3	−5	+ 2	0
− 3	+4	0	+1	− 4	+3	+2	+1	+ 4	−5	+ 3	+2

7. By such assumptions the residuals can be considerably reduced. If these empirical explanations stood alone they might not be worth much; but as suggested by the independent discussions quoted, it would seem that they are worth careful attention.

Bizarre Conclusion derived from Einstein's Gravitation Theory. By L. Silberstein, Ph.D., Lecturer in Mathematical Physics at the University of Rome.

By Einstein's amplified "field equations" the world-curvature is, within matter,

$$G = \kappa T + 4\lambda,$$

and outside of matter,

$$G = G_0 = 4\lambda,$$

where, according to Einstein, λ is a positive constant, the meaning of the remaining symbols being as in de Sitter's papers (*M.N.*, 76, 706; 77, 6).

If pressures, molecular forces, etc., within the body are neglected, then $T = \rho$, the density of gravitating mass. Now, imagine a body which, in certain co-ordinates ct, x, y, z, occupies a portion τ of the corresponding three-space, bounded by a surface σ; and let ρ be constant throughout the body. To fix the ideas, let the co-ordinate system be such that the *three-space* curvatures are given by $G_1 G_0$ themselves, these being the minimal curvatures possible in the said four-manifolds, by a famous theorem of Beltrami-Killing (cf. Killing, *cit. infra*, p. 79). Then we should have a space-region of some constant positive curvature proportional to

$$G = G_0 + \kappa\rho,$$

surrounded by space whose curvature is proportional to G_0. For the sake of uniformity of notation write $G_0 = 12/R_0^2$, $G_0 + \kappa\rho = 12/R^2$, so that R_0, R will be the radii of world-curvature without and within the body. We need not trouble about the corresponding, internal and external, gravitational fields or the g_{ij} entering into the line-elements. It is enough to know that R_0 has some constant real value outside of τ, and $R > R_0$ some other constant value inside τ. Thus, if we fix the time, say $t = 0$, the boundary σ of the body will be determined, in Weierstrass space-coordinates x_1, x_2, x_3, x_4, by the "intersection" of the two four-dimensional spheres

$$x_1^2 + x_2^2 + x_3^2 + x_4^2 = R^2,$$
$$(x_1 - a_1)^2 + \ \ldots\ + (x_4 - a_4)^2 = R_0^2,$$

where a_i are constants. Eliminating Σx_i^2 we have, for the boundary σ,

$$\Sigma a_i x_i = \frac{1}{2R_0}[R^2 - R_0^2 + \Sigma a_i^2] = \text{const.},$$

which is the equation of a sphere,* similarly as the intersection of two ordinary spheres is a circle. In order to visualise the above result, imagine a two-dimensional space of some constant positive curvature surrounded by another of another constant positive curvature, a spherical dome set upon a larger spherical surface, say.

Thus Einstein's theory would yield the absurd conclusion:

A homogeneous body, or lump of matter, can have only the shape of a sphere.

I call this conclusion "absurd" not in the sense of a self-contradiction, of course, but in the more familiar sense of something which it is hard to adhere to.

The above result is valid for $T \div \rho$, *i.e.* neglecting internal stresses, molecular forces, and so on. But taking them into account would certainly not help the matter very much, owing to the extreme smallness of the corresponding terms. A possible escape might consist in assuming an appropriate transition layer, in which R passes gradually to R_0, or in fitting out each atom of "matter" with a rigorously spherical shape. This, however, would hardly be a satisfactory defence of Einstein's theory. For it certainly has not started with the idea of a necessarily atomistic structure of matter. Again, apart from gravitation (which, after all, is only a special phenomenon), the chief object of general relativity is to give an intrinsic or generally covariant description of Nature. And, obviously, the mere requirement of the covariance of our language cannot induce Nature to shape all her bodies spherically, nor force any behaviour whatever upon any phenomena.

What has been shown above for R_0^2 positive or nil can, with obvious modifications, be repeated for negative curvature of the exterior world, a curvature which, by the way, is discarded by Einstein and his followers.

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Note (of data given at the May meeting of R.A.S.) added May 20.—It may be well to mention that the curvature increase inside matter is, comparatively speaking, by no means small. Thus, for water ($\rho = 1$ c.g.s.), I find, by the formula

$$12\left(\frac{1}{R^2} - \frac{1}{R_0^2}\right) = \kappa\rho,$$

$$\frac{1}{R^2} = \frac{1}{R_0^2} + \frac{0{\cdot}000142}{a^2},$$

* *Cf.* Killing's *Nicht-Euklidische Raumformen*, Leipzig, 1885, or any treatise on non-euclidean geometry.

where $a \doteqdot 1{\cdot}5 \cdot 10^8$ km. is the astronomical unit of length; and since, at any rate, $|R_0| > 10^7 a$, and, therefore, $1 : |R_0^2| < 10^{-14} a^{-2}$, we have, with more than sufficient accuracy, for water,

$$\frac{1}{R^2} = \frac{\cdot 00142}{a^2},$$

and d times this for any other medium of "specific gravity" d. This means, for instance, an excess of the angle sum in a triangle of area Δ,

$$\Sigma - \pi = \cdot 00142 \frac{\Delta \cdot d}{a^2} = \frac{\Delta \cdot d}{a^2} 4''{\cdot}88.$$

The corresponding curvature-radius is

$$R = 26{\cdot}5 \frac{a}{\sqrt{d}}.$$

Even for (ordinary) homogeneous air the angle excess would be as great as

$$\frac{\Delta}{a^2} 0''{\cdot}38,$$

and so on.

The Surface Currents of Jupiter during the Apparition of 1917–18. By Scriven Bolton.

During the apparition of 1917–18 Jupiter was observed with the 26-inch reflector from 1917 September 24 to 1918 May 3 inclusive, the opposition of the planet occurring on 1917 November 28. The work undertaken is a continuance of that done during the apparitions of 1915–16 and 1916–17 (*M.N.*, 76, 634, and 77, 460), *i.e.* a determination of the longitudinal drift of the surface matter in different latitudes in order to ascertain the several independent periods of rotation of the planet's surface. Accordingly, the number of recorded transits across the central meridian of Jupiter totalled 6437. Of these, 409 were excluded in the final reduction. The results have been enhanced in value by the accumulation, during the apparition, of 391 reference drawings. The markings specified in the annexed table of rotation periods may be identified by reference to a chart published in *M.N.*, 77, 462.

Table of Mean Rotation Periods of Markings in Different Latitudes.

Markings recorded.	Approximate Latitude.	Number of Selected Spots.	Average Number of Selected C.M. Transits.	Total Number of C.M. Transits obtained.	Date of First Observation.	Date of Last Observation.	Mean Rotation Period.
	°				1917.	1918.	h m s
S. Polar Band. Dark spots and streaks	−51	2	9	29	Nov. 10	Feb. 15	9 55 42·5
	−51	19	10	190	,, 10	,, 15	9 55 23·8
S.S. Temperate Zone. White spots	−45	24	11	284	Sept. 30	Mar. 9	9 55 9·0
S.S. Temperate Band. Dark spots and streaks	−41	36	9	123	,, 30	,, 9	9 55 8·4
S.S. Temperate Band. Light spots	−41	17	6	338	,, 26	,, 10	9 55 7·3
S. Temperate Zone. White spots	−32	26	13	359	Nov. 10	,, 10	9 55 25·8
S. Temperate Band. Dark spots	−29	24	13	343	Sept. 25	,, 9	9 55 25·3
S. Tropical Zone. White spots	−21	16	11	179	,, 26	,, 9	9 55 32·2
S. Equatorial Belt, S. edge. Dark crests	−18½	12	14	181	,, 25	,, 9	9 55 32·6
Red Spot Hollow. Both shoulders	−18½	2	19	37	,, 25	Apr. 30	9 55 34·1
White spots on Red Spot	−19½	2	5	10	,, 26	Jan. 12	9 55 33·9
S. Tropical Disturbance. *p* end at S. Equatorial Belt	−18½	1	19	19	Oct. 5	Apr. 27	9 55 25·7
S. Tropical Disturbance. *f* end at S. Equatorial Belt	−18½	1	22	22	Sept. 29	May 3	9 55 32·4
S. Tropical Disturbance. Interior dark spots	−18 to −26	8	11	85	,, 29	Apr. 27	9 55 38·4
S. Tropical Disturbance. Interior light spots	−18 to −26	6	13	90	Oct. 1	Feb. 8	9 55 38·0
S. Equatorial Belt. Light spots in central rift	−14	13	6	103	Sept. 29	,, 15	9 55 36·0
S. Equatorial Belt, N. edge. Dark spots	− 9	24	12	320	Oct. 1	Mar. 10	9 50 14·5
Equatorial Band. Dark streaks	± 0	28	10	283	Sept. 25	,, 9	9 50 14·4
N. Equatorial Belt. S. edge. White spots	+ 7	23	12	294	Oct. 5	,, 10	9 50 13·8
N. Equatorial Belt. S. edge. Dark spots	+ 7½	31	13	400	Sept. 24	,, 10	9 50 13·9
N. Equatorial Belt. N. edge. White spots	+17	21	13	279	,, 24	,, 9	9 55 24·8
N. Equatorial Belt. N. edge. Dark spots	+14	23	11	250	,, 25	,, 9	9 55 24·0
N. Temperate Band. S. edge. Dark spots	+22	28	9	272	,, 26	,, 9	9 55 26·1
N. Temperate Band. N. edge. Dark spots	+24	32	11	367	,, 25	,, 10	9 55 26·2
N. Temperate Zone. White spots	+29	26	12	329	,, 25	,, 9	9 55 29·6
N.N. Temperate Band. Dark spots and streaks	+36	12	13	174	,, 25	,, 9	9 55 52·8
N.N. Temperate Band. Dark spots and streaks	+36	7	11	124	,, 25	,, 9	9 55 24·2
N.N. Temperate Zone. White spots	+45	9	8	155	,, 26	,, 8	9 55 52·9
N.N. Temperate Zone. White spots	+45	15	11	163	,, 26	,, 8	9 55 23·1
N. Polar Band. Dark spots and streaks	+49	30	11	362	,, 29	,, 9	9 55 28·2
N. Polar Region. Light spots	+54	11	8	111	Oct. 1	,, 9	9 55 46·0
N. Polar Region. Dark spots and streaks	+57	21	7	162	,, 14	,, 5	9 55 52·0
Totals	...	550	...	6437	...	...	...
Average	...	17·2	11·3	201·2	Oct. 11	Mar. 29	...

Table of Mean Rotation Periods of Markings in Different Latitudes—continued.

Markings recorded.	Approximate Latitude.	Number of Selected Spots.	Average Number of Selected C.M. Transits.	Total Number of C.M. Transits obtained.	Date of First Observation.	Date of Last Observation.	Mean Rotation Period.
	°				1917.	1918.	h m s
Equatorial Current	− 9 to + 7½	106	11·8	1297	Sept. 27	Mar. 10	9 50 14·2
p and *f* ends of S. Tropical Disturbance	− 18½	2	20·5	41	Oct. 2	Apr. 27	9 55 29·1
Ditto, with interior light and dark spots	− 18 to − 26	16	16·0	216	,, 1	,, 27	9 55 33·7
All S.S. Temperate spots	− 45 to − 41	77	8·7	745	Sept. 29	Mar. 9	9 55 8·2
All N.N. Temperate spots	− 36 to − 45	21	10·5	329	,, 26	,, 9	9 55 52·9
	− 36 to − 45	22	11·0	287	,, 26	,, 9	9 55 23·7

Red Spot Hollow, during unobserved interval 1917 Feb. 6 to Sept. 26 = 9 55 34·3

S. Tropical Disturbance { *p* end during unobserved interval 1917 Feb. 2 to Oct. 5 = 9 55 22·4
{ *f* end during unobserved interval 1917 Feb. 6 to Sept. 29 = 9 55 28·3

In approximately lat. 57° N., which represents the northernmost latitude where the rate of motion of the surface was ascertained, there existed a faint dark band situated within the N. Polar region. The dark spots and streaks here exhibited a slow rotation period of $9^h\ 55^m\ 52^s{\cdot}0$.

Along the N. edge of the N. Polar Band (*i.e.* within the N. Polar region) were manifested a number of light spots, eleven of which gave a rotation period of $9^h\ 55^m\ 46^s{\cdot}0$.

From a mean of the two currents alluded to we get, for the N. Polar region, a period of $9^h\ 55^m\ 49^s{\cdot}0$. In 1915–16 the result arrived at for this region was $9^h\ 55^m\ 45^s{\cdot}9$.

The rotation period of the N. Polar Band, as given in the table, is in reasonable agreement with that derived in 1916–17, the difference amounting to $-1{\cdot}6$ seconds.

As indicated in the table of rotation periods, the dark spots along the N.N. Temperate Band and the light spots in the N.N. Temperate Zone exhibited in each case two relatively independent and well-marked currents. Features in these latitudes have in the past shown a wide variation in their rates of velocity. Where the two currents merged gently together, an intermediate rate of velocity was manifested thus:—

Region.	Number of Selected Spots.	Number of Selected C.M. Transits.	Date of First Observation.	Date of Last Observation.	Mean Rotation Period.
			1917.	1918.	h m s
N.N. Temperate Band	4	8	Oct. 4	Jan. 1	9 55 39·7
N.N. Temperate Zone	7	9	,, 1	Feb. 8	9 55 37·4

Slow Current (on *p* side).	Intermediate Current.	Swift Current (on *f* side).
h m s	h m s	h m s
9 55 52·9	9 55 38·6	9 55 23·7

The Equatorial Current exhibited a noteworthy acceleration of velocity, the period of rotation diminishing from $9^h\ 50^m\ 26^s{\cdot}3$ in 1915–16 to $9^h\ 50^m\ 14^s{\cdot}2$ in 1917–18.

The Great S. Tropical Disturbance was in conjunction with the Red Spot Hollow, the latter, at the end of March, being situated midway between the two ends. The Disturbance extended nearly half way round the globe, its average length during the apparition amounting to roughly 170° of longitude. While the portion preceding the Hollow faded out completely early in the apparition, the preceding end itself exhibited renewed activity. The dark matter which issued forth at this point rapidly distended itself towards the Hollow, and at the end of April had almost reached that object, thus restoring the normal intensity of this portion of the Disturbance. The interior light and dark markings of the Disturbance drifted at a slower rate than did the preceding and following ends. Incidentally, the Hollow exhibited a rate of motion intermediate to these two currents. The lagging behind of the interior markings relatively to the Hollow is shown by the following figures :—

Interior Markings.	Mean Number of C.M. Transits.	Date of First Observation.	Date of Last Observation.	Mean Rotation Period.	Rotation Period of Hollow.	Difference.
		1917.	1918.			
3 spots (p the Hollow)	12·3	Oct. 1	Apr. 27	h m s	h m s	
11 spots (f the Hollow)	11·7	Sept. 29	Feb. 8	9 55 38·2	9 55 34·1	+4·1 seconds

This relative retrogression caused the dark material on the following side of the Hollow to drift away from the shoulder, and by February 5 it was clear of that object by an interval of 12°.

The white spots along the S. Tropical Zone, together with the shallow bays on the S. edge of the S. Equatorial Belt containing them, slowed down in the region preceding the S. Tropical Disturbance, whereas for some distance following the Disturbance they manifested a decidedly quickened velocity.

The S. Polar Band contained two dark spots whose rates of motion were indicative of a current slower than that exhibited simultaneously by the rest of the band. Their longitudinal positions on January 1 were approximately 27° and 46° respectively, and their mean periods of rotation are included in the table of rotation periods.

A series of alternating light and dark meridians was frequently manifested from the tropics to the poles, at which times the spots representing the different currents were arranged in meridional rows, and exhibited temporarily one rate of motion not dissimilar to that of the Red Spot.

It not infrequently occurred that small areas in the white zones, which appeared shaded prior to reaching the central meridian, were, after passing the same, gradually transformed into white areas.

The Red Spot represented an ellipse with slightly pointed ends,

and appeared as a faint neutral stain situated symmetrically in the Hollow. It was in contact with the S. Temperate Band. At the extreme following end lay a small black spot. In the margin between the Red Spot and the Hollow were several small bead-like spots. Across the southern portion of the Red Spot lay a faint dark streak running parallel with the S. Temperate Band. Two white spots situated on the Spot itself are included in the table of rotation periods.

The planet was bathed in a delicate claret hue. The average colours of the belts and poles were as follows:—The N.N. and S.S. Temperate Bands, and both polar regions, a dull yet decided claret; S. Temperate Band, ruddy; S. Equatorial Belt, dull brick red; N. Equatorial Belt, dull cherry red; N. Temperate Band, reddish brown. The zones, milky white.

Bramley, Yorkshire:
May 15.

Twelfth Note on the Number of Faint Stars with Large Proper Motions. Zone +25°. By F. A. Bellamy, M.A.

References to the previous notes of this series are:—*M.N.*, **69**, 57, 491; **71**, 45, 582; **72**, 65; **74**, 26, 27; **76**, 102, 428, 538, 657.

The twelfth note deals with eight pairs of plates, besides two duplicate pairs containing interesting stars, in Zone + 25°, taken at intervals ranging from 16 to 23 years.

The form of the comparison and reductions is precisely that adopted for previous notes; also the arrangement of the material in Tables I. and II.

TABLE I.

Stars with probable large P.Ms. Zone +25°.

R.A. Plate Centre. h m	Total Stars compared.	Interval in Years.	Total P.Ms.	Centennial P.Ms. Above 15″.	Below 15″.
13 32	72	23·00	13	4	9
14 20	73	16·97	10	4	6
14 20	45	23·03	8	5	3
15 0	80	16·97	5	2	3
15 0	65	23·02	8	2	6
15 24	126	22·93	3	1	2
16 20	166	22·93	6	0	6
16 44	163	16·98	8	0	8
17 24	282	16·83	8	1	7
17 32	316	16·83	9	1	8
8 plates	1278		63	14	49

In the summary of Table I. the two duplicate plates with 17 years' interval have not been included. Thus, 1 star in 20·3 stars shows evidence above 6″·5 c.p.m.; 1 in 26 below 15″ c.p.m.; and 1 in 91 above 15″ c.p.m.—ratios in fair agreement with the numbers in the fifth note of this series.

Some of the stars given in Table II. have already appeared in former notes, but those were derived from much shorter intervals between the two plates. Others have also been given. These occur on overlapping regions photographed; often not well placed for the best measurement, being near the margins of the plates.

The unit for Δx and Δy in Table II. is ·001 of a réseau interval (0″·3). The ϕ magnitude is deduced from the measured diameter, using the formula given in the printed astrographic zones for Oxford.

TABLE II.

List of P. Ms. in Zone +25°.

R.A. of Plate Centre.	Oxford No. in +25°.	ϕ Mag.	A.G.C. No.	Δx.	Δy.	Cent. P.M. in Arc.	Interval in Years.
h m							
14 20	42915*	9·8	B 5073	+ ·062	− ·087	139″·8	23·03
14 20	42907*	9·4	B 5072	+ ·063	− ·085	137·9	23·03
14 20	42915*	9·8	B 5073	+ ·047	− ·063	138·9	16·97
14 20	42907*	9·4	B 5072	+ ·046	− ·063	138·6	16·97
15 0	44446*	9·8	C 7086	− ·066	+ ·038	101·1	23·02
15 0	44446*	9·8	C 7086	− ·049	+ ·029	99·7	16·97
14 20	42937	10·3		− ·027	+ ·004	48·3	16·97
15 0	44437*	4·7	C 7084	+ ·011	− ·011	27·4	16·97
14 20	43037*	7·5	C 6848	− ·017	+ ·011	26·4	23·03
15 0	44437*	4·7	C 7084	+ ·015	− ·008	22·3	23·02
14 20	43037*	7·5	C 6848	− ·010	+ ·007	21·6	16·97
13 32	42104*	9·0	B 4838	− ·008	− ·013	19·9	23·00
	84520*	9·0					
13 32	42148	9·3		− ·014	+ ·003	18·7	23·00
	84742	9·6					
14 20	43180*	5·6	C 6814	− ·013	+ ·006	18·7	23·03
13 32	42134*	6·4	C 6514	+ ·005	− ·013	18·2	23·00
	84322*	6·3					
17 24	50944*	9·3	C 8249	− ·006	+ ·008	16·3	16·83
14 20	43100*	9·2	C 6812	− ·010	+ ·007	15·9	23·03
15 24	45234	10·3		+ ·001	− ·012	15·8	22·93
13 32	42102	10·4		+ ·001	− ·012	15·7	23·00
	84506	9·8					
17 32	51283	12·6		− ·006	+ ·006	15·1	16·83
17 24	50974	12·1		− ·008	+ ·002	14·7	16·83

TABLE II.—*continued.*

R.A. of Plate Centre.	Oxford No. in + 25°.	φ Mag.	A.G.C. No.	Δx.	Δy.	Cent. P.M. in Arc.	Interval in Years.
h m						″	
15 24	45221	10·3		− ·010	+ ·005	14·7	22·93
14 20	43100*	9·2	C 6812	− ·007	+ ·004	14·3	16·97
16 20	47223	10·7		− ·006	− ·009	14·2	22·93
15 0	44408	9·7		− ·006	− ·005	13·8	16·97
17 24	50777	11·1		− ·003	+ ·007	13·6	16·83
14 20	42946	9·8		+ ·003	− ·007	13·5	16·97
17 32	51317	12·2		+ ·002	+ ·007	13·0	16·83
17 32	51169	10·1		+ ·004	− ·006	12·9	16·83
14 20	43062	10·3		− ·001	+ ·007	12·5	16·97
17 32	51174	11·2		·000	+ ·007	12·5	16·83
13 32	42117	10·1		− ·009	+ ·003	12·4	23·00
	84592	10·2					
13 32	42101	9·9		− ·006	− ·007	12·0	23·00
	84503	8·5					
17 24	50762	12·4		+ ·006	− ·003	12·0	16·83
17 32	51173	11·6		− ·006	− ·003	12·0	16·83
16 44	47965	11·8		+ ·006	− ·003	11·9	16·98
16 20	47263*	9·3	C 7664	− ·008	+ ·004	11·7	22·93
15 0	44421	10·1		− ·004	− ·008	11·6	23·02
16 20	47270	11·0		+ ·005	− ·007	11·3	22·93
14 20	43180*	5·6	C 6814	− ·006	+ ·004	11·2	16·97
16 20	47267*	9·6	C 7624	− ·006	− ·006	11·1	22·93
13 32	42123	9·3		+ ·006	− ·006	11·1	23·00
	84613	10·0					
17 24	50851	11·7		+ ·006	− ·001	10·8	16·83
17 24	50887*	9·3	C 8183	− ·006	− ·001	10·8	16·83
16 44	47899	9·7		+ ·001	+ ·006	10·8	16·98
13 32	42141	10·5		− ·001	− ·008	10·5	23·00
	84720	10·8					
14 20	43168	10·0		+ ·005	− ·003	10·3	16·97
16 44	47839	12·0		+ ·004	− ·004	10·0	16·98
14 20	43136	10·3		+ ·004	+ ·004	10·0	16·97
16 20	47243	10·8		+ ·003	+ ·007	10·0	22·93
17 32	51232	10·1		+ ·005	+ ·002	9·6	16·83
17 32	51315*	8·2	C 8285	+ ·002	+ ·005	9·6	16·83
17 24	50909	12·1		+ ·005	− ·002	9·6	16·83
15 24	45206*	8·3	B 5325	− ·007	+ ·002	9·6	22·93
16 44	47890	10·6		− ·002	+ ·005	9·5	16·98

TABLE II.—*continued.*

R.A. of Plate Centre.	Oxford No. in +25°.	φ Mag.	A.G.C. No.	Δx.	Δy.	Cent. P.M. in Arc.	Interval in Years.
h m						"	
16 44	47900	12·2		− ·005	+ ·002	9·5	16·98
14 20	43163	9·0		− ·004	− ·006	9·4	23·03
16 20	47249	10·5		− ·007	− ·001	9·3	22·93
14 20	42948	9·6		+ ·007	− ·001	9·2	23·03
13 32	42113	9·2		+ ·007	·000	9·1	23·00
	84556	8·5					
15 0	44320	11·4		·000	− ·007	9·1	23·02
17 32	51331	12·4		+ ·005	− ·001	9·1	16·83
16 44	47897	12·2		+ ·001	− ·005	9·0	16·98
15 0	44316*	8·5	B 5215	+ ·005	+ ·001	9·0	16·97
17 24	50732	12·4		+ ·003	+ ·004	8·9	16·83
17 32	51177	11·2		·006	+ ·005	8·9	16·83
16 44	47807	12·0		·000	− ·005	8·9	16·98
16 44	47830	10·6		+ ·003	+ ·004	8·9	16·98
15 0	44367	10·1		+ ·005	·000	8·8	16·97
13 32	42120	9·2		− ·005	+ ·004	8·3	23·00
	84602	9·6					
15 0	44316*	8·5	B 5215	+ ·004	+ ·005	8·3	23·02
13 32	42147	10·8		+ ·006	·002	8·2	23·00
	84762	10·8					
13 32	42132*	8·8	C 6552	+ ·001	+ ·006	7·9	23·00
	84653*	8·5					
15 0	44458	11·2		− ·006	+ ·001	7·9	23·02
15 0	44445	10·0		+ ·004	− ·003	6·8	23·02
13 32	42172	9·3		− ·005	+ ·001	6·7	23·00
	84876	9·6					
14 20	43062	10·3		·000	+ ·005	6·5	23·03
15 0	44432*	8·3		− ·004	+ ·003	6·5	23·02

The limit adopted for inclusion of proper motions in this note is $(\Delta x)^2 + (\Delta y)^2 = 25$, as formerly.

The second number given for the centre R.A. $13^h\ 32^m$ refers to the plate (2831) measures in the Oxford Astrographic Catalogue $+25^\circ$, pp. 220–222.

University Observatory, Oxford:
1918 *May* 9.

Micrometrical Measures of Thirty-one New Double Stars.

By Frederick C. Leonard.

The following thirty-one new double stars (viz. Nos. 3–33 inclusive of the subjoined list, with the exception of Nos. 20 and 21, detected with the 6½-inch equatorial of the Students' Observatory of the University of Chicago) were found, during the summer of 1917, with the 12-inch Brashear refractor of the Yerkes Observatory, at Williams Bay, Wis. For the sake of completeness, my first and second stars, discovered previously (the former with the 12-inch, the latter with the 6½-inch), are also included in the accompanying list, the measures being reprinted from the original source of publication, *Popular Astronomy*, **24**, 613, and **25**, 340–1 respectively.

I desire to express my deep obligation to Professor Georges Van Biesbroeck, who has very kindly measured the great majority of these stars with the 40-inch refractor of the Yerkes Observatory. I have likewise to thank Professor E. E. Barnard for measuring No. 14 with the large telescope; and, finally, Professor Eric Doolittle, of the Flower Observatory, for checking all of these pairs by reference to his manuscript catalogue of the extension of Burnham's "General Catalogue of Double Stars."

My own measures of eight of the new stars were obtained with the 12-inch telescope. It should be promptly added, however, that, in most cases, unless the conditions of seeing are exceptional, as they rarely are, the *measurement* of such pairs with a 12-inch aperture is attended with extreme difficulty. I therefore attach to my measures of these stars little more weight than mere "micrometrical estimates," so-called, should carry.

The limit of separation adopted in this work was 5″·00.

The measure of each star is marked by the initials of the observer who secured it. After the position of each catalogued star, are given, in order, the (combined) magnitude as tabulated in the Durchmusterung, and the individual magnitudes of the components as estimated by me independently at the time of discovery, or shortly thereafter. The estimates of magnitudes recorded by the other observers are also included with their measures. By the term "anonymous" is meant only that the star in question does not occur in the Durchmusterung: the position of such a star has been differentially determined from that of a neighbouring Durchmusterung star. The positions of all of these doubles are for the epoch 1880·0.

No.	Star.	1880·0. R.A.	1880·0. Dec.	Combined Mag. in Durch.	Mags. estimated by F.C.L.	Mags. estimated by Observer.	Position-Angle.	Distance.	No. of Nights.	Date.	Observer.
		h m s	° ′	m	m m	m m	°	″			
3	Anon.	0 34 53	− 8 20	..	11·0 11·1	11·0 11·3	7·7	2·12	2	1917·769	B.
4	B.D.+55° 280	1 10 17	+55 38	9·4	9·2 10·3	9·5 10·5	89·6	3·45	3	·658	B.
5	Anon.	2 10 56	+53 48	..	10·1 10·3	10·0 10·4	338·7	4·35	2	·769	B.
6	B.D.−0° 386	2 28 34	+ 0 5	9·2	9·0 9·7	9·5 10·3	156·3	2·00	2	·804	B.
7	B.D.+60° 558	2 34 36	+60 52	9·5	..	..	..	..	..	..	..
	A.B.	..	..	..	9·1 10·1	..	7·1	1·75	3	·704	L.
	A.C.	..	..	..	9·1 14·0	..	7±	18±	..	..	L.
8	Anon.	2 34 38	+59 27	..	9·7 10·2	..	143·2	2·79	3	·704	L.
9	B.D.+40° 583	2 36 46	+40 35	9·5	10·1 10·4	10·0 10·5	203·2	3·36	2	·769	B.
10	B.D.+52° 651	2 53 52	+52 14	9·5	10·1 10·2	10·4 10·6	80·2	2·84	2	·769	B.
11	Anon.	5 11 47	+60 4	..	9·7 10·2	..	205·5	2·74	3	·704	L.
2	B.D.+0° 1068	5 20 45	+ 0 32	9·5	9·8 10·2	..	88·5	2·53	4	·109	L.
12	Anon.	14 45 6	+11 20	..	10·0 10·7	11·1 11·3	148·5	3·47	2	·534	B.
13	S.D. 20° 4475	16 14 50	−20 14	10·0	10·0 13·0	10·2 12·7	282·1	3·96	2	·534	B.
14	S.D. 3° 4187	17 45 33	− 3 27	9·1	9·3 10·5	9·4 9·9	60·8	1·07	3	·506	B.
15	S.D. 19° 4924	18 7 56	−19 15	9·0	..	..	..	..	..	..	..
	A.B.	..	...	..	9·0 12·5	9·5 12·3	116·2	3·84	2	·699	B.
	A.C.	..	..	..	9·0 13·0	9·5 12·5	301·3	8·13	2	·699	B.
1	B.D.+40° 3309	18 8 10	+40 13	9·4	9·8 10·4	..	152·8	1·38	2	1916·718	L.
16	S.D. 19° 4985	18 16 45	−19 34	9·4	9·8 10·1	10·0 10·3	49·3	1·09	3	1917·588	B.
17	Anon.	18 20 22	−18 43	..	..	..	..	..	..	..	..
	A.B.	..	..	..	10·7 10·9	10·7 11·1	210·5	4·28	3	·708	B.
	A.C.	..	..	..	10·7 13·7	10·7 13·5	275·5	17·13	1	·691	B.
18	C.D.−23° 14379	18 20 43	−23 32	9·3	9·6 10·1	9·5 10·7	296·0	2·71	3	·532	B.
19	Anon.	18 29 49	−18 39	..	11·0 12·3	10·8 12·0	249·7	3·34	2	·709	B.
20	S.D. 14° 5134	18 29 54	−14 3	9·1	..	..	..	..	..	..	..
	A.B.	..	..	..	9·0 9·6	9·6 10·3	258·2	3·99	2	·699	B.
	A.C.	..	..	..	9·0 10·2	..	105±	30±	..	..	L.
21	Anon.	18 37 29	−14 51	..	..	..	..	..	..	..	..
	A.B.	..	..	..	9·7 10·1	10·1 10·8	15·2	4·29	3	·707	B.
	A.C.	..	..	..	9·7 10·5	..	270±	35–40±	..	..	L.
22	C.D.−23° 14893	18 50 44	−23 46	9·4	9·8 10·2	10·0 10·6	283·8	2·72	3	·532	B.
23	Anon.	18 51 27	−14 3	..	10·5 10·9	10·7 11·0	202·9	4·29	3	·565	B.
24	S.D. 7° 4810	18 54 6	− 7 37	9·8	..	..	..	..	..	..	..
	A.B.	..	..	..	9·8 11·1	9·8 11·9	33·9	4·72	4	·565	B.
	A.C.	..	..	..	..	9·8 13·8	315·8	22·66	2	·536	B.
	A.D.	..	..	..	..	9·8 12·1	35·4	27·13	2	·536	B.
25	S.D. 15° 5286	19 8 2	−15 10	9·4	..	..	..	..	..	..	..
	A.B.	..	..	..	9·6 10·1	..	59·4	0·72	3	·701	L.
	A.C.	..	..	..	9·6 14·2	..	288±	30±	..	..	L.
26	S.D. 17° 5591	19 13 47	−17 9	9·5	9·8 10·1	10·1 10·5	100·4	2·54	2	·699	B.
27	S.D 17° 6292	21 22 37	−17 51	9·4	9·9 10·0	10·0 10·3	0·1	3·48	3	·695	B.
28	Anon.	21 32 45	+49 9	..	10·4 10·5	..	158·2	2·36	3	·729	L.
29	S.D. 16° 6070	22 16 2	−16 27	8·5	8·2 9·4	..	91·4	3·71	3	·708	L.
30	S.D. 18° 6229	22 52 49	−18 14	9·5	9·9 10·1	10·0 10·3	86·5	3·38	2	·769	B.
31	B.D. 56° 3008	23 21 8	+56 30	9·3	9·2 10·5	9·4 11·0	1·3	2·99	2	·694	B.
32	S.D. 9° 6246	23 38 2	− 9 43	9·5	9·3 9·7	..	20·0	4·81	3	·732	L.
33	S.D. 20° 6651	23 40 34	−20 29	9·8	10·0 10·2	..	164·5	2·46	1	·729	L.
	..	..	..	..	..	10·5 10·7	166·0	2·50	1	·763	B.

No. of Star. *Notes.*

5. Another star, $9^m{\cdot}6$ at $0°\pm$, distant $30'' - 35''\pm$, estimated by F.C.L.
2. The stars B.D. $+0°{\cdot}1067$ ($9^m{\cdot}5$) and 1069 ($9^m{\cdot}4$) in the same telescopic field with this double are both relatively wide pairs. The measure of this star was secured with the $6\frac{1}{2}$-inch.
14. My estimates of magnitude (made with the 12-inch) probably indicate too large a disparity in magnitude between the components. In the 40-inch they appeared more nearly equal in brightness, the difference seeming to be approximately half a magnitude, as Professor Barnard's estimates tend to show. S.D. $3°{\cdot}4186$ ($9^m{\cdot}2$) is very near in the telescopic field.
1. Colour of the components, white and pale blue.
19. A number of minute stars near the double.
20. A.C. Rough visual estimates.
21. A.C. Coarse visual estimates.
24. C. added by Van Biesbroeck with the 40-inch.
25. The measure in distance is probably slightly too small. C ($14^m{\cdot}2$) detected Sept. 16.
26. S.D. $17°{\cdot}5593$ ($9^m{\cdot}4$), a wide pair, near.
28. A rather wide faint pair a short distance *following*.
31. Companion greenish in lowest ocular. B.D. $+56°{\cdot}3010$ ($9^m{\cdot}1$), a double in which the separation exceeds $5''$, is near.

1338 *Madison Park,*
Chicago, Ill., U.S.A.:
1917 *Dec.* 28.

Micrometrical Measures of Double Stars. By Rev. T. E. R. Phillips, M.A.

The stars in the following list were measured in 1917 with the 8-inch refractor belonging to the Society. Special attention was again given to ξ Boötis and 70 Ophiuchi.

Star.	1920. R.A.	Dec.	Mag.	Position-Angle.	Distance.	No. of Nights.	Date.
	h m	° ′		°	″		
OΣ 12 (λ Cassiop.)	0 27·3	+54 5	5·6, 5·9	159·3	0·60	3	1917·778
Σ 60 (η Cassiop.)	0 44·0	57 24	4·0, 7·6	255·4	6·92	4	·624
73 (36 Androm.)	0 50·7	23 12	6·2, 6·8	45·9	0·71	3	·671
149	1 39·8	39 33	8·2, 9·7	100·1	1·33	3	·745
180 (γ Arietis)	1 49·1	18 54	4·2, 4.4	359·6	8·00	3	·872
186	1 51·7	1 27	7·2, 7·2	39·7	0·95	3	·716
202 (α Piscium)	1 57·9	2 23	2·8, 3·9	313·3	2·76	3	·723
OΣ 38 (γ^2 Androm.)	1 59·0	41 57	5·0, 6·2	112·7	0·56	6	·683
Σ 228	2 8·9	47 6	6·7, 7·6	116·1	0·63	3	·959
262 (ι Cassiop.) A.B.	2 22·4	67 3	4·2, 7·1	252·2	1·99	3	·810
A.C.	...	...	4·2, 8·1	111·7	7·23	2	·829
305	2 42·9	19 2	7·3, 8·2	314·9	3·32	3	·864
333 (ε Arietis)	2 54·6	21 2	5·7, 6·0	203·3	1·42	3	·717
380	3 17·4	8 29	8·3, 9·3	56·1	0·90	3	·916
535	4 18·8	11 12	6·7, 8·2	323·9	1·47	2	·945

Star.	1920. R.A. h m	Dec. ° ′	Mag.	Position-Angle. °	Distance. ″	No. of Nights.	Date.
Σ 559	4 28·9	+17 51	7·0, 7·0	275·8	3·02	2	1917·945
OΣ 95	5 0·8	19 42	6·5, 7·0	324·6	0·67	3	·807
Σ 644	5 4·9	37 12	6·7, 7·0	220·6	1·88	3	·864
716 (118 Tauri)	5 24·3	25 5	5·8, 6·6	202·7	4·70	3	·874
OΣ 170	7 13·3	9 26	7·5, 7·5	102·3	1·73	3	·923
175	7 30·1	31 9	6·0, 6·6	328·0	0·75	3	·333
Σ 1110 (Castor)	7 29·5	32 4	2·7, 3·7	217·5	4·96	3	·864
1126	7 35·8	5 24	7·2, 7·5	148·5	1·28	2	·954
1196 (ζ Cancri) A.B.	8 7·6	17 54	5·5, 6·2	296·1	0·76	5	·302
1356 (ω Leonis)	9 24·2	9 25	6·2, 7·2	124·9	0·94	3	·216
1424 (γ Leonis)	10 15·5	20 15	2·0, 3·5	116·5	3·66	4	·208
1670 (γ Virginis)	12 37·7	− 1 0	3·6, 3·6	323·8	5·78	3	·402
1865 (ζ Boötis)	14 37·3	+14 4	3·5, 3·9	139·0	0·76	6	·327
1877 (ε Boötis)	14 41·5	27 21	3·0, 6·3	330·8	2·77	2	·338
1888 (ξ Boötis)	14 47·7	19 26	4·7, 6·6	83·2	2·12	4	·229
				83·1	2·22	5	·379
				83·6	2·25	5	·438
				84·0	2·29	5	·520
				84·5	2·20	6	·679
	Mean of all measures :—			83·7	2·22	25	·468
1932 (1 Coronæ)	15 14·9	27 7	5·6, 6·1	11·5	0·60	3	·652
1937 (η Coronæ)	15 19·9	30 34	5·5, 6·0	63·9	0·69	4	·291
2032 (σ Coronæ)	16 11·7	34 1	5·0, 6·1	217·9	4·99	3	·492
2140 (α Herculis)	17 11·0	14 29	3·0, 6·1	110·5	4·42	5	·721
2272 (70 Ophiuchi)	18 1·4	2 31	4·1, 6·1	137·1	4·86	5	·361
				137·0	4·95	5	·474
				136·2	4·97	5	·584
				136·1	4·84	5	·672
				135·6	4·78	5	·816
	Mean of all measures :—			136·4	4·88	25	·581
2382 (ϵ^1 Lyræ)	18 41·7	39 35	4·6, 6·3	8·6	2·80	3	·352
2383 (ϵ^2 Lyræ)	...	...	4·9, 5·2	119·6	2·31	3	·352
2525	19 23·3	27 9	7·4, 7·6	305·2	0·74	3	·547
Aitken 864	19 37·5	72 56	8·8, 9·0	37·0	0·80	2	·318
Σ 2579 (δ Cygni)	19 42·5	44 55	3·0, 7·9	282·4	1·73	4	·392
2583 (π Aquilæ)	19 44·9	10 25	6·0, 6·8	113·1	1·52	3	·785
2603 (ε Draconis)	19 48·5	70 4	4·0, 7·6	7·0	2·79	3	·321
2605 (ψ Cygni)	19 53·6	52 13	5 0, 7·5	180·8	3·04	2	·319
OΣ 413 (λ Cygni)	20 44·3	36 12	5·0, 6·3	51·2	0·63	3	·620
437	21 17·5	32 7	6·5, 7·2	37·9	1·82	3	·910
Σ 2799	21 25·6	10 44	6·6, 6·6	291·1	1·64	3	·910
2822 (μ Cygni)	21 40·5	28 23	4·0, 5·0	133·3	1·39	3	·666
β 75	21 51·5	10 30	8·0, 8·5	49·7	0·75	3	·910
172	22 19·9	− 5 15	6·5, 6·5	353·7	0·59	3	·919
Σ 2909	22 24·7	0 26	4·0, 4·1	306·0	2·73	3	·675
OΣ 483 (52 Pegasi)	22 55·2	+11 18	6·2, 7·7	233·4	0·79	3	·699
Σ 3050	23 55·4	33 17	6·0, 6·0	223·9	2·14	3	·699

Notes.

Σ 1888 (ξ Boötis). The measures in 1917 are puzzling. The angle should still be diminishing somewhat rapidly, but the figures make the comes practically stationary. It is difficult to attribute the discordance entirely to systematic error, as such an effect is not apparent in the measures of 1916.

Σ 2272 (70 Ophiuchi). The measures do not show anything remarkable in 1917.

Σ 2579 (δ Cygni). This is usually considered a difficult pair. The comes is sometimes apparently invisible even in large instruments, and is often best observed in twilight. But in 1917 it was conspicuously easy to see and measure, and is perhaps variable.

Σ 2822 (μ Cygni). The orbit plane is presented nearly edgewise, and the pair is closing rapidly.

Observations of Sirius and Procyon made with the 28-inch Refractor of the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The following measures of the companion to Sirius are a continuation of those printed in the *Observatory*, **40**, 203, and the *Astronomical Journal*, No. 721.

The estimated magnitude of the companion is given in the fourth column.

t.	*θ.*	*r.*	Mag.	*n.*
	°	″		
1918·077	71·2	10·50	10·0	1
·079	71·0	10·64	10·0	2
·082	70·5	10·65	10·4	1
·085	69·3	10·37	12·0	1
·126	69·9	10·45	9·6	2
·134	69·8	11·04	10·6	1
·162	70·6	10·44	9·7	1
·192	71·5	10·59	9·2	1
·214	71·9	...	9·7	1
·216	71·7	10·86	9·6	2
·222	72·3	...	10·5	1
·225	71·9	10·54	9·7	2
·230	71·5	...	10·2	1

All these observations were made with the full aperture of the 28-inch refractor, and with a power of 450. When two sets of measures were made on the same night, these were obtained some little time apart, when it was found that the definition had remained sufficiently good. There are 17 measures made on 13 nights. Each position is the mean of 5 measures in position-angle and 6 in distance.

The mean result is:

t.	*θ.*	*r.*	Mag.	*n.*
1918·16	71°·0	10″·64	10·0	13

The greatest observed brightness of the companion was 9·2. Last year it was once observed as bright as 9·1; in 1916, 9·5; and in 1915, 9·3. It seems that at Greenwich, under the best conditions, one may expect to find the companion as bright as 9·0 B.D.

On the nights when the visibility of Sirius's companion was satisfactory, the large refractor was immediately turned on Procyon in the hope of seeing the companion, but the result was usually negative. On the tenth night, however, the following measure was obtained of a speck of light near Procyon which may possibly have been the companion:—

t.	*θ.*	*r.*
1918·22	58°·8	4″·63

This was apparently the only night when the definition was good enough, for it was not seen again, although the beginning of this year has not been unfavourable. The measures of Sirius are already only possible under fair atmospheric conditions.

The observations were made by Mr. R. Jonckheere.

Royal Observatory, Greenwich:
1918 *April* 30.

The Period of Sirius. By R. Jonckheere.

(*Communicated by the Astronomer Royal.*)

The companion to Sirius is now more easily observable than it has been for forty years, and as it has completed a revolution since the discovery in 1862, a study of the present observations is of special interest.

During the last four winters, Sirius has been observed on 30 nights with the 28-inch refractor of the Royal Observatory, Greenwich. The means of these measures give the following results:—

t.	*θ.*	*r.*	Mag.	*n.*
1915·04	78°·9	9″·94	10·6	8
1916·11	74·6	10·57	10·6	6
1917·23	73·9	10·61	9·4	3
1918·16	71·0	10·64	10·0	13

Professor E. E. Barnard, during the same period, has published measures made on 34 nights with the 40-inch refractor of Yerkes Observatory. His means are :—

$t.$	$\theta.$	$r.$	$n.$
	°	″	
1915·99	75·1	10·66	15
1916·95	73·8	10·80	19

Comparing all these observations with the orbits of See, Doberck, and Lohse, I obtain the residuals $(o - c)$ given below :—

See (1895).

Obs.	$t.$	$\theta_o - \theta_c.$	$r_o - r_c.$	$r_o - \rho.$
		°	″	″
J	1915·04	−3·6	−0·07	−0·36
B	1915·99	−5·2	+0·39	−0·01
J	1916·11	−5·5	+0·29	−0·13
B	1916·95	−4·3	+0·40	+0·03
J	1917·23	−3·7	+0·18	−0·15
J	1918·16	−4·4	−0·01	−0·33

Doberck (1903).

Obs.	$t.$	$\theta_o - \theta_c.$	$r_o - r_c.$	$r_o - \rho.$
		°	″	″
J	1915·04	+2·2	−0·59	−0·36
B	1915·99	+0·4	−0·08	−0·04
J	1916·11	+0·1	−0·19	−0·18
B	1916·95	+1·0	−0·12	−0·03
J	1917·23	+1·7	−0·34	−0·20
J	1918·16	+0·8	−0·45	−0·40

Lohse (1908).

Obs.	$t.$	$\theta_o - \theta_c.$	$r_o - r_c.$	$r_o - \rho.$
		°	″	″
J	1915·04	+2·4	−0·44	−0·18
B	1915·99	+0·7	+0·06	+0·13
J	1916·11	+0·4	−0·05	0·00
B	1916·95	+1·3	+0·02	+0·14
J	1917·23	+2·0	−0·21	−0·03
J	1918·16	+1·0	−0·32	−0·25

ρ is the tabular distance corresponding with the observed θ.

The mean correction to these orbits for the arc here described is :—

Obs.	Orbit.	$\theta_o - \theta_c$.	$r_o - r_c$.	$r_o - \rho$.
B	See	$-4^\circ\cdot8$	$+0''\cdot40$	$+0''\cdot01$
J	,,	$-4\cdot3$	$+0\cdot10$	$-0\cdot24$
B	Doberck	$+0\cdot7$	$-0\cdot10$	$-0\cdot03$
J	,,	$+1\cdot2$	$-0\cdot39$	$-0\cdot28$
B	Lohse	$+1\cdot0$	$+0\cdot04$	$+0\cdot13$
J	,,	$+1\cdot4$	$-0\cdot25$	$-0\cdot11$

In the interval from 1915 to 1918 See's value of θ_c diminishes by $6^\circ\cdot7$, that is, 1° in 0·45 year, $\theta_o - \theta_c$ could therefore be taken as corresponding in time to $-4^\circ\cdot8 \times 0\cdot45 = -2\cdot16$ years. Assuming the other elements to be correct, the correction to the respective periods would then give in this way :—

Obs.	Orbit.	Period.	Correction.	Corrected Period.
B	See	52·20	−2·16	50·04
J	,,	,,	−1·94	50·26
B	Doberck	49·49	+0·35	49·84
J	,,	,,	+0·60	50·09
B	Lohse	49·32	+0·48	49·80
J	,,	,,	+0·67	49·99

Practically the same correction is found by making $\theta_c = \theta_o$ and finding $t_o - t_c$ or using $\tan(\theta - \Omega) = \cos i \tan(\omega + v)$ to find v_o and v_c, hence

$$\frac{m_o - m_c}{n}.$$

This method is only a rough approximation, but it is, I believe, permissible with the material dealt with, since the observations used in deducing the orbits were, in the main, made in the same quadrant nearly one revolution earlier, and the elements are already very good.

Another independent value of the period can now be obtained for the first time by simply comparing the corresponding dates showing the same position angles in the preceding revolution.

The dates from 1864–1868 are interpolated from the tabulated values given by Burnham. The early observations of the companion are unfortunately not very reliable.

Obs.	θ.	t_1.	t.	$(t_1 - t)$.
J	$78^\circ\cdot9$	1915·04	1864·43	50·61
B	75·1	1915·99	1866·08	49·91
J	74·6	1916·11	1866·32	49·79
J	73·9	1917·23	1866·62	50·61
B	73·8	1916·95	1866·69	50·26
J	71·0	1918·16	1868·68	49·48

Collecting all these results:

	B.	J.
By comparison with the preceding revolution	50·08	50·12
By approximate correction to the three orbits	49·89	50·12

Giving double weight to Barnard's measures, the mean is 50·02. It is difficult to decide whether the approximate method of correction applied to the orbits, which are based on all the observations, is worthy of more weight than the direct comparison with the poor observations of 1864–1868. It seems, however, that for the present, the period of revolution of the Sirian system can be taken as 50 years.

Twenty orbits of Sirius have already been computed. That of Zwiers, used by Lewis Boss in his Preliminary Catalogue, has a period of 48·84, which is the shortest ever given. Gore in 1888 gave the longest period of 58·47. Burnham's period was 51·80.

Peters in 1851, that is 11 years before the discovery of the companion, made an extensive investigation of the orbit of Sirius, mostly from the Greenwich transit observations, and although the maximum displacement was only $0^{s}\cdot152$, he calculated from these observations a period of 50·01 which, from the above study, appears to be correct and superior to most periods given since from the visual observations of the companion. Auwers in 1864, employing almost the same material as that used by Peters, but with the addition of two years' visual observations of the companion, computed a period of 49·42.

For a parallax of $0''\cdot38$ and a semi-major axis of $7''\cdot5$, a change of period from 49 to 50 years alters the mass of the system from 3·20 to 3·07 times the sun's mass. See in 1895, with the elements of his orbit and the same parallax, gave 3·47.

Royal Observatory, Greenwich:
1918 *May* 4.

On a New Variable Star in Auriga. By A. Stanley Williams.

R.A. $= 5^{h}\ 05^{m}\ 20^{s}$, Decl. $= +39^{\circ}\ 53'\cdot9$ (1855).
„ $= 5^{h}\ 08^{m}\ 27^{s}$, „ $= +39^{\circ}\ 57'\cdot5$ (1900).

The variability of this star was first noticed towards the end of 1905 or the beginning of 1906 when comparing two photographs taken with a 4·4-inch portrait lens. On one of these, dated 1901 Jan. 14, the star was bright; whilst on the other, dated 1901 Jan. 22, it was relatively faint. On a third plate, dated Feb. 20 in the same year, it was again relatively bright. A series of visual observations was commenced in 1906 with the object of determin-

ing the elements and type of variation. By 1907 Mar. 20 observations had been obtained on 48 nights, but, with the exception of three observations in 1907, there is then a break in the series extending to the autumn of 1911, when, however, only four observations were made, followed by another long break. Finally, the work of observation was resumed in the autumn of last year. Altogether there are observations on 67 nights available. These were all made with a 6½-inch reflector, a power of 73 being, with one exception, uniformly employed.

The positions of the variable and the comparison stars used

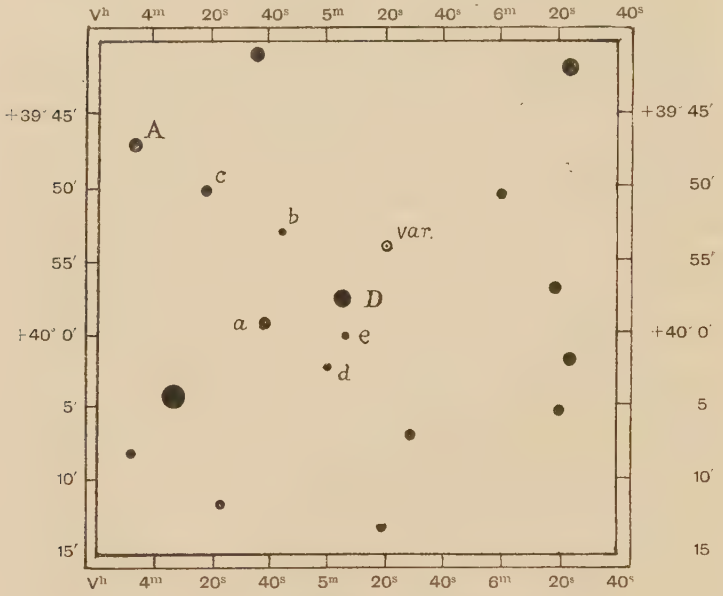

FIG. 1.—Variable Star in Auriga.

will be clear from the adjoining little chart, with regard to which it should be remarked that the positions of the comparison stars b, d, and e are very rough, being mere rough estimations. Also that there are a great many faint stars which do not appear in it at all. The place of the variable with respect to the star D* (B.D. +39° 1225, 8·8 mag.) was measured directly with a position micrometer on the 6½-inch reflector on 1917 Dec. 5. According to these measures it followed D by 13ˢ·3, and was 3′·5 south of the same. Adopting the B.D. position of D, the place of the variable for 1855 and 1900 is as stated at the heading of this paper.

* This star D is the variable 44·1908 Aurigæ, discovered at Harvard. This fact was not known at the time when the observations were made, and as it was not used as a comparison star for brightness, its variability was not noticed.

Owing to the fact that only very few variable star observations had been made by the observer for several years preceding 1917, it was thought advisable to form separate light-scales from the earlier and later observations respectively. Table I. contains in the first column the designation of the comparison star; in the second and third columns the B.D. number and magnitude; in the fourth the light-scale formed from the observations prior to 1917; and in the fifth column that derived from those of the last-mentioned year. It will be seen that there is little difference between the two light-scales. No. 2 is slightly more contracted than No. 1. The two scales were therefore combined into a third light-scale (No. 3), and this latter alone was used for the reduction of the observations. The last column contains the magnitudes on the assumptions that the magnitude of A is 9·10 and the value of a step is 0·06 magnitude.

TABLE I

Star.	B.D. No.	Mag.	Light-scale.			Mag.
	°		(1)	(2)	(3)	
A	+39 1215	9·1	42·7	37·6	39·6	9·10
a	+39 1221	9·3	37·9	...	36·0	9·32
c	+39 1217	9·3	28·7	25·7	27·2	9·84
b	...	...	14·6	12·9	13·7	10·65
d	...	...	12·6	12·2	12·4	10·73
e	...	...	10·0	10·0	10·0	10·88

The observations are given in detail in Table II. The first column contains the date and G.M.T. of the observation; the second the Julian date corresponding thereto; the third the interval T from the last preceding maximum (Elements I.); the fourth the actual observations; the fifth the deduced brightness in steps according to the light-scale (3); and the last column the state of the sky (I. = bad to IV. = very good). The estimations were made partly according to the fractional method, and partly according to the ordinary Argelander method. No attempt was made to make the value of a step conform to any specific fraction of a star magnitude. The usual precautions were taken, particularly the very important one of making all comparisons with a straight line joining the two stars compared parallel to a similar line through the two eyes. All the observations, with one exception, were made with the same eye-piece, magnifying 73 times, on the 6½-inch reflector. The means have been taken in cases where there are two series of observations on the same night.

TABLE II.

Date.	h m	J.D. 241 +	T.	Observations.	Brightness.	Sky.
1906						
April 13	8 47	7314·4	6·0	a8v4b, c10v, v10e, v7d	19·5	IV.
13	9 25	...	...	c7v5b	...	IV.
14	9 00	7315·4	7·0	b5v, c14v, v4d, v10e	14·6	IV.
15	8 30	7316·4	8·0	b5v, c12v, v2d, v8e	14·2	IV.
15	9 40	...	...	b4v, c12v, v3d, v7e	...	IV.
16	9 00	7317·4	9·0	b5v, c14v, v5d, v9e	14·6	IV.
19	9 18	7320·4	12·0	b9v, d5v1e	9·9	III.
23	9 05	7324·4	16·0	v7d, v10e, b6v, c15v	14·3	I.
23	9 10	...	...	b5v, c17v, v5d, v9e	...	I.
25	9 17	7326·4	18·0	c7v5b, v10d, v15e	21·5	IV.
26	9 08	7327·4	0·6	c5v14b, v17d, v20e, a14v	24·4	IV.
27	9 15	7328·4	1·6	c7v12b, v18d, v22e, a16v	24·0	I.
28	9 04	7329·4	2·6	c8v11b, v13d, v18e	21·8	III.
30	9 50	7331·4	4·6	c12v5b, v10d, v15e	19·4	I.
Aug. 21	15 24	7444·6	7·7	c12vob, v2d, v5e	14·2	IV.
22	15 17	7445·6	8·7	c17v, b2v, dov2e	11·6	IV.
27	14 45	7450·6	13·7	c15v, b4v, v3d, v5e	13·1	III.
28	14 54	7451·6	14·7	c15v, vob, v5d, v7e	15·1	IV.
29	15 02	7452·6	15·7	c14v, vob, v1d, v4e	13·6	IV.
30	15 00	7453·6	16·7	c10v5b, v4d, v6e	17·2	IV.
31	15 48	7454·7	17·8	c2v16b, v16d, v18e, a8v	25·9	IV.
Sept. 1	15 43	7455·7	0·4	c5v14b, v10d, v13e	21·5	IV.
2	14 37	7456·6	1·3	c3v13b, v8d, v9e, a10v	22·7	IV.
6	14 25	7460·6	7·3	c13v7b, v8d, v10e	17·8	II.
9	16 05	7463·7	10·4	v2d, v3e, a21v, c16v1b	13·6	I.
10	15 05	7464·6	11·3	c18v, b1v, v1d, v3e	12·4	I.
10	15 14	...	...	c17v, bov, vod, v2e	...	II.
11	14 28	7465·6	12·3	b2v, vod, v1e	11·7	IV.
12	16 12	7466·7	13·4	b4v, d2v0e	10·0	IV.
15	14 47	7469·6	16·3	bov, v3d, v4e	14·3	I.
15	15 02	...	...	c17v, v2b, v3d, v4e	...	IV.
24	15 35	7478·6	4·9	c10v, v5b, v3d, v5e	16·6	IV.
25	13 42	7479·6	5·9	c8v, v5b, v3d, v5e	17·1	IV.
26	14 14	7480·6	6·9	c11v, v4b, v2d, v4e	15·6	IV.
27	16 37	7481·7	8·0	c13v, v2d, v2b, v5e	14·9	III.
29	14 10	7483·6	9·9	b3v, d2v2e	11·0	II.
Oct. 5	15 51	7489·7	16·0	c10v, v7b, v7d, v5e	18·1	III.
6	13 05	7490·5	16·8	cov16b, v15d, v17e, a16v	25·2	III.

TABLE II.—*continued.*

Date.	h m	J.D.	T.	Observations.	Brightness.	Sky.
1906		241+				
Oct. 10	13 35	7494·6	2·6	c6v10b, v10d, v10e	20·8	II.
13	13 36	7497·6	5·6	c15v, b0v, v3d, v5e	14·1	IV.
14	14 52	7498·6	6·6	c15v, v0b, v2d, v3e	13·3	IV.
23	11 46	7507·5	15·5	c14v, b0b, v3d, v4e	14·1	IV.
25	12 18	7509·5	17·5	v4c, v15b, b12d, v14e, a9v	27·1	II.
27	12 10	7511·5	1·1	c7v8b, v15v, v10d, v12e	21·3	IV.
28	12 13	7512·5	2·1	c7v8b, v8d, v10e	20·1	IV.
Nov. 11	11 00	7526·5	16·1	c11v, v6b, v3d, v5e	16·1	III.
17	13 12	7532·6	3·9	(c6v4b), v7d, v9e	19·2	I.
Dec. 7	8 42	7552·4	5·3	c15v, b2v, v3d, v5e	13·6	III.
9	11 32	7554·5	7·4	v0b, d1v, v2e	13·4	IV.
21	11 18	7566·5	1·1	c9v9b, v12d, v15e	20·9	III.
1907						
Jan. 11	11 10	7587·5	3·7	c10v4b, v7d, v10e	18·6	III.
17	9 27	7593·4	9·6	b5v, v0d, v2e	11·0	IV.
Mar. 20	9 27	7655·4	16·5	c5v12b, v6d, v8e	20·0	IV.
Sept. 7	14 45	7826·6	4·1	v1d, v2e, b1v, c12v	13·3	IV.
9	15 00	7828·6	6·1	v0d, v2e, b2v, c10v	13·3	IV.
Dec. 5	10 45	7915·5	1·2	v5d, v7e, c12v, b3v	15·1	III.
1911						
Sept. 22	16 00	9302·7	11·6	a14v, b1v, d5v, e0v	11·3	IV.
Oct. 17	14 27	9327·6	18·1	v0c, v10b, v5d, v8e	21·6	III.
Nov. 5	12 30	9346·5	0·3	v1c, v10b, A13v, v15d, v15e	26·0	III.
Dec. 11	10 00	9382·4	17·9	v7d, v7e, c5v9b	20·3	III.
1917		242+				
Oct. 10	11 02	1512·5	0·1	c7v10b, v10d, v12e	20·7	IV.
17	10 20	1519·4	7·0	A13c12v2b, v=d, v2e	13·8	III.
21	10 15	1523·4	11·0	A13c12b2v, d2v, e0v	12·8	III.
26	9 40	1528·4	16·0	A17c11v3b, v3d, v5e	15·8	III.
27	9 40	1529·4	17·0	c5v9b, v10d, v12e	22·3	I.
28	10 00	1530·4	18·0	c7v8b, v13d, v15e	22·3	I.
Nov. 25	8 05	1558·3	9·2	b5v, v3e	10·8	I.
Dec. 2	?	1565·3	16 2	A10c2v9b, v12d, v14e	25·9	II.
3	7 00	1566·3	17·2	c2v10b, A12v	25·4	I.
5	?	1568·3	0·8	A10v, v0c, v12b, v10d, v12e	25·4	IV.
9	7 35	1572·3	4·8	c7v3b, v7d, v10e	20·2	III.
12	7 00	1575·3	7·5	d2v1e, A10c10v0b	12·2	II.

Notes.—1906 Apr. 27, hazy. Apr. 30, power 110 used. Sept. 15, thin cloud about. Sept. 24, thin cloud about. Oct. 10, much thin cloud about. Nov. 17, cloud about and comparison with b and c certainly affected by same. 1911 Sept. 22, "a14v" treated as c14v. 1917 Oct. 27, much cloud about. Oct. 28, much cloud about. Nov. 25, an imperfect glimpse through cloud. Dec. 2, much passing cloud. Dec. 9, some cloud about.

On most nights the star was compared with c and b by the fractional method, from which the "step value for the night" could be ascertained, and the other observations were then usually reduced by this step value. All the observations were, however, reduced before any attempt was made at discussing them. A preliminary investigation then enabled the following elements of variation (Elements I.) to be derived,

$$\text{Maximum} = \text{J.D. } 2417326{\cdot}8 + 18^{d}{\cdot}358\ \text{E.}$$

Column 3 of Table II. gives the intervals by which the observations follow the last preceding maximum, and the observations were then arranged in groups of four * and the means taken. These means are given in Table III., and are shown by dots in the diagram (fig. 2) of the mean light curve.

TABLE III.

Phase. d	Brightness.	Phase. d	Brightness.
0·35	23·1	8·42	13·8
1·05	20·7	9·77	11·6
1·90	22·1	11·47	11·6
3·57	18·0	13·52	12·5
4·90	17·4	15·80	15·0
5·90	16·0	16·22	16·7
6·87	14·3	17·00	22·9
7·55	14·4	17·96	22·3

It will be seen from the light curve that the variation is of the ordinary Cepheid type, but that, as is so commonly the case, there are distinct signs of irregularity about the time of maximum. In particular, the existence of a secondary maximum about $2\frac{1}{2}$ days after the chief maximum seems highly probable.

As it appeared that some improvement in the elements of variation might result from a further discussion, the times of ten maxima and six minima were carefully ascertained by means of the light curve (fig. 2), and from these the following corrected elements (Elements II.) were derived:

$$\text{Maximum} = \text{J.D. } 2417326{\cdot}5 + 18^{d}{\cdot}3563\ \text{E.}$$
$$\text{Minimum} = \text{J.D. } 2417319{\cdot}5 + 18^{d}{\cdot}3563\ \text{E.}$$

* The last group contains five observations. The observations of 1917 Dec. 2 and Dec. 30 have been rejected, both having been made under poor conditions, and the former making the star considerably too bright.

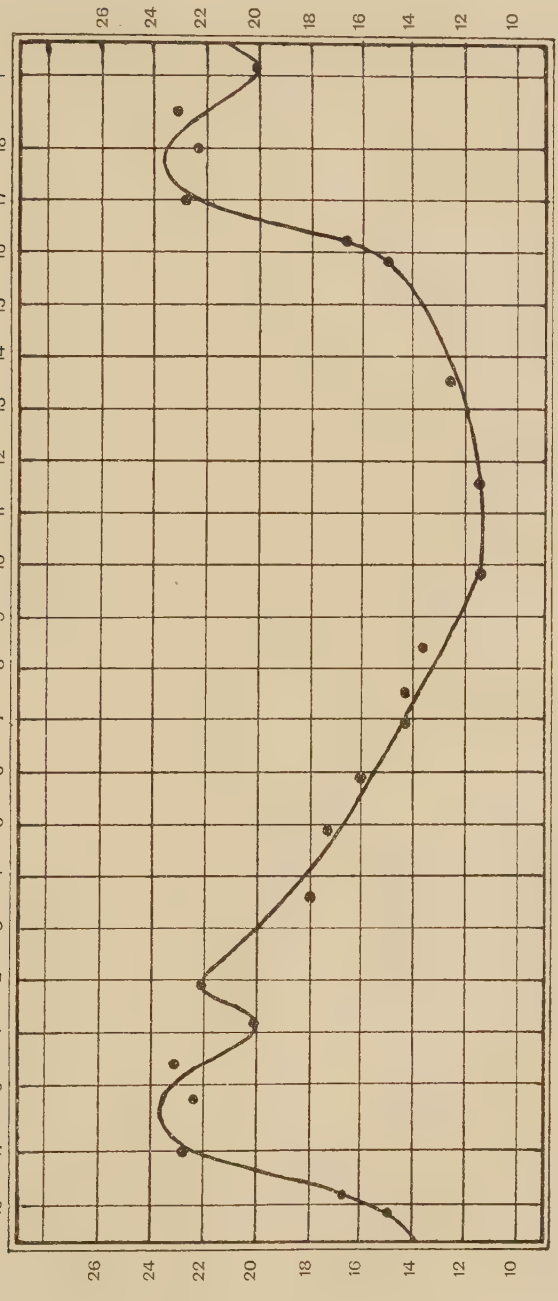

Fig. 2.—Mean Light Curve of Variable in Auriga.

Table IV. contains the observed and computed times of maximum and minimum, with the residuals O − C.

TABLE IV.

(*a*) *Maxima.*

E.	Observed.	Wt.	Computed.	O − C.
				d
0	2417327·4	3	26·50	+0·90
7	7455·0	3	54·99	+0·01
8	7473·7	1	73·35	+0·35
9	7491·1	3	91·71	−0·61
10	7509·7	3	10·06	−0·36
11	7528·4	1	28·42	−0·02
109	9328·5	1	27·34	+1·16
110	9347·0	1	45·69	+1·31
229	2421530·0	2	30·09	−0·09
231	1566·5	1	66·81	−0·31

(*b*) *Minima.*

0	2417320·7	2	19·50	+1·20
8	7466·6	2	66·35	+0·25
9	7484·4	2	84·71	−0·31
10	7502·5	2	03·06	−0·56
15	7594·2	1	94·84	−0·64
229	2421523·2	3	23·09	+0·11

Summary.

(1) The variation is of the Cepheid type.
(2) Period of variation = 18·3563 days.
(3) Maximum brightness = 24·0 steps (10·04 mag.).
(4) Minimum brightness = 11·5 steps (10·79 mag.).
(5) Range = 12·5 steps (0·75 mag.).
(6) Interval from minimum to maximum = 7·0 days.

Polvarth, St. Mawes:
1918 *April* 29.

Baxendell's Observations of Variable Stars. Tenth Instalment. Nos. 25, U Boötis; 26, U Canis Minoris; 27, χ Cygni; 28, U Herculis; 29, R Scuti. Edited by H. H. Turner and Mary A. Blagg.

No. 25, *U Boötis* (5338 *Chandler*).

$14^h\ 47^m\ 37^s$	$+18°\ 17'{\cdot}1$	(1855·0)
14 49 42	+18 6·0	(1900·0)

Baxendell notes that this variable was discovered 1880 Mar. 12; but in 1866–7 there is a series of observations of a star under the name of U Boötis, which, however, was "invisible" on each occasion (with A 68), except once when it was "suspected." This was presumably a different star from the one discovered in 1880.

Identification of Comparison Stars.—In this case, although there are seventeen small sketches and one chart, and the designations of three of the stars vary very considerably, the identification presents no serious difficulties. The star *b* of the chart was often called "comp. U," "comp. to the north," or "star below." The stars *b*, *d*, and *e* of the chart are not in Harvard, but the magnitudes in brackets have been obtained by calculation from the A.S.V. grades, from comparison of the grades and Harvard magnitudes of those stars which are given in both. Baxendell evidently saw the star called 3 fainter, and that called 13 brighter than their Harvard magnitudes, and the adopted magnitudes are therefore slightly modified from those of Harvard.

Table I.

Baxendell's Comparison Stars for U Boötis.

Chart.	A.S.V.		Harvard.		Adopted Mag.
	No.	Grade.	Let.	Mag.	
3	1	0	*a*	7·78	80
13	4	27	*e*	9·95	·96
2	7	36	*h*	10·54	105
a	9	45	*k*	10·99	110
b	13	59	...	(11·90)	118
d	15	67	...	(12·16)	122
e	16	71	...	(12·29)	124

Stars 3, 13, 2, *a* of the chart are consistently so designated where used in the sketches.

Star *b* appears as *b* on 1880 July 20, 1881 July 8, 1884 May 18 and Sept. 12; as *c* on 1880 Apr. 2, 1881 Apr. 17 and Oct. 16; as *m* on 1882 Apr. 20; as *x* on 1883 Oct. 27; and as *a* on 1884 Mar. 25.

Star *d* appears as *c* on 1880 May 9 and July 20, 1881 June 27, and 1884 May 18; as *d* on 1881 May 4; as *n* on 1882 Apr. 20;

as *y* on 1883 Oct. 27; as *m* on 1885 May 11 and 16; and as *e* on 1886 Feb. 26.

Star *e* appears as *o* on 1882 Apr. 20; as *x* on 1884 Mar. 25; and as *d* on 1884 May 18.

TABLE II.

Baxendell's Differences between his Comparison Stars.

	Years.	96-80.	105-96.	110-105.	118-110.	122-118.	124-122.	110-96.
Bax., sen., 1880-1		15·5$_{11}$	10·6$_{29}$	4·7$_{22}$	9·9$_{13}$	6·1$_{8}$	...	15·0$_{11}$
	1882-3	...	13·4$_{6}$	3·6$_{9}$	15·0$_{2}$	4·5$_{1}$	4·0$_{1}$	18·1$_{4}$
	1884-7	...	10·0$_{19}$	4·2$_{58}$	8·0$_{2}$	8·6$_{6}$	2·5$_{1}$	14·5$_{2}$
	Mean	15·5	10·7	4·4	10·3	7·0	3·25	15·7
	No. of Obs.	11	54	39	17	15	2	17
	Reduced Mean	12·5	9·1	3·7	8·4	5·8	3·0	12·7
Bax., jun., 1885-91		...	6·2$_{10}$	3·5$_{11}$	7·8$_{7}$	4·0$_{5}$	2·1$_{4}$	9·0$_{4}$

Some observations by Mr. J. Baxendell, junior, have been included, in order to increase the material for discussion. It will be seen that he makes the star called 13 about 3-tenths fainter than it appeared to Baxendell, senior, while there is little difference in other cases between his intervals and the "reduced mean" as given above. In reducing his observations, therefore, this star has been taken as 99 (in agreement with Harvard) instead of 96. Mr. Baxendell, junior, himself noted this difference in estimation, in 1887.

The telescope used was E 80.

TABLE III.

Observations of U Boötis.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.	Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1880	240+			1880	240+		
Mar. 13	7788	80+10, 96−2, 105−7, 110−8	96	Mar. 24	7799	80+11, 96−3	92
				25	7800	96−3	93
14	7789	80+11, 96−3, 105−9, 110−11	95	Apr. 1	7807	80+10, 96−1	92
				2	7808	80+11, 96−1, 110−11	95
15	7790	80+10, 96−2, 105−9	93				
				4	7810	96+0	96
17	7792	80+10, 96−2, 105−10	93	8	7814	80+12, 96+2, 105−7	96
19	7794	80+10, 96−3	92	9	7815	96+2	98
21	7796	80+11, 96−3	92	11	7817	96+2	98

1880 Mar 14, hazy. Mar. 15, clearer.

TABLE III.—*Observations of U Boötis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1880	240+		
Apr. 16	7822	96+5, 105−2	102
17	7823	96+5, 105−3	102
19	7825	96+8, 105−1, 110−6	104
22	7828	96+11, 110−5, 105−0	106
24	7830	105+2, 110−3	107
25	7831	105+3, 110−2	108
29	7835	105+7, 118−6, 110+2, 96+14	112
30	7836	105+6, 110+2, 118−5	112
May 1	7837	110+1, 118−3	113
3	7839	110+5, 118−0	116
5	7841	110+7, 118+1	118
6	7842	118+0, 110+7	118
7	7843	118+1	119
9	7845	118+3, 122−1	121
10	7846	118+5, 122+0	122
12	7848	118+6, 122+3, min. vis. −10	124
14	7850	122+3, 118+10, min. vis. −6	126
15	7851	122+6, 118+11, min. vis. −8	128
16	7852	122+6	128
17	7853	122+7	129
27	7863	Not seen <122+6	
June 4	7871	,, <122+8	
9	7876	,, <135	
July 4	7901	Glimpsed 122+6	128
9	7906	122+7, min. vis. −3	129
20	7917	118+4, 122−2	121
29	7926	110−1, 118−5	111
July 31	7928	110−1	109
Aug. 6	7934	105+2, 110−2, 118−9	108
9	7937	110−2	108
12	7940	105−1, 110−3	106
13	7941	105−2, 110−3	105
16	7944	105−3, 110−6	103
24	7952	96+4, 105−6	100
28	7956	96+4, 105−8	98
29	7957	96+6, 105−6	100
31	7959	96+3, 105−8	98
Sept. 3	7962	96+0, 105−10	96
5	7964	96−1	95
8	7967	96−2	94
13	7972	96−1	95
16	7975	96−2	94
18	7977	96−2	94
26	7985	96+2, 105−8	98
28	7987	96+3, 105−7	98
Oct. 2	7991	96+2, 105−7	98
3	7992	96+3, 105−6	99
9	7998	96+7, 105−2	103
10	7999	96+8, 105−2	104
17	8006	105+5	110
21	8010	105+5, 110−2	109
29	8018	110+9, 118−1	118
1881			
Mar. 28	8168	96+3, 105−5, 110−7	101
31	8171	96+3, 105−6	99
Apr. 6	8177	96+7, 105+1, 110−4	105
8	8179	96+11, 105+0, 110−4	106

1880 May 27, strong twilight.
1880 July 20, ☽, difficult.
1880 Oct. 17, haze and ☽.
July 9, strong twilight and clouds.
Aug. 29, very low.
Oct. 21, low.
Oct. 29, difficult.

TABLE III.—*Observations of U Böotis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1881	240+		
Apr. 17	8188	105+6, 118−7	111
20	8191	105+9, 118−3	114
23	8194	105+11, 118+1	118
May 4	8205	122+7,	129
		min. vis. −6	
7	8208	122+8,	130
		min. vis. −4	
9	8210	* 118+9 (glimpsed)	127
20	8221	122+9,	131
		min. vis. −2	
22	8223	* 118+9	127
		(glimpsed occ.)	
29	8230	Not seen < 118+8	
June 27	8259	122+2	124
July 8	8270	118−4	114
11	8273	110+7, 118−8	114
14	8276	110+0	110
17	8279	105+6, 110−2	110
19	8281	110−4	106
20	8282	105+2, 110−4	106
27	8289	96+6, 110−5	104
Aug. 1	8294	96+2, 105−7	98
24	8317	96−3	93
30	8323	96−3	93
Sept. 1	8325	96−3	93
14	8338	96+3, 105−4	100
19	8343	96+3, 105−6	99
25	8349	96+3, 105−3	100
Oct. 2	8356	110+1	111
8	8362	110+5	115
16	8370	118+3	121
20	8374	About 118+7	? 125
29	8383	Not seen low and)	
1882			
Mar. 8	8513	96−1, 105−9	96
12	8517	96−1, 105−7	96
Mar. 16	8521	96+5, 105−6, 110−8	101
18	8523	96+9, 105−5, 110−7	103
20	8525	96+9, 105−5, 110−6	103
Apr. 3	8539	< 110+6	
6	8542	110+5, 118−12	110
10	8546	118−1, 110+7	117
20	8556	118+6, 122+3, min. vis. −14	124
May 4	8570	122+6 (glimpsed)	128
12	8578	124+7, min. vis. −5	131
16	8582	13·0 est.	
19	8585	13·0 ,,	
July 9	8636	105+1, 110−5	106
24	8651	96+2	98
26	8653	96−2	94
29	8656	96−3	93
Aug. 19	8677	96−3	93
28	8686	96−3	93
Sept. 9	8698	96+2	98
11	8700	96+2	98
13	8702	96+3	99
1883			
Mar. 4	8874	105−2, 110−7	103
12	8882	96+9, 105−3, 110−6	104
24	8894	105+3, 110−1	108
26	8896	110+4	114
Apr. 8	8909	118+0	118
July 28	9020	96−1	95
,,	,,	96−2	94
Aug. 25	9048	96+3	99
Oct. 27	9111	118+7, 122+1	124

* ? *c* written for *d*, which had usually been called *c*, and was so called again, June 27.

TABLE III.—*Observations of U Böotis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1884	240+		
Feb. 25	9232	96+4, 105−3	101
Mar. 16	9252	118+0	118
21	9257	118+3	121
25	9261	118+5, 124+1	124
Apr. 28	9295	About 13·3	
May 18	9315	118+8, 122+0	124
22	9319	118+5, 122+1	123
26	9323	118+6, 122−1	122
30	9327	118+3, 122−4	120
June 11	9339	105+3, 110−3	108
20	9348	110−5, 105−3	104
25	9353	105−1, 110−5	104
July 2	9360	105−2, 110−6	104
6	9364	96+4, 105−3	101
12	9370	96+2, 105−5	99
16	9374	96+3, 105−4	100
19	9377	96+2, 105−6	98
23	9381	96+1, 105−6	98
25	9383	96+1, 105−7	98
27	9385	96+2, 105−6	98
Aug. 1	9390	96+1, 105−8	97
6	9395	96+2, 105−6	98
11	9400	96+2, 105−7	98
14	9403	96+2, 105−5	99
19	9408	96+1, 105−8	97
23	9412	96+5, 105−4	101
Sept. 1	9421	105+3, 110−1	108
12	9432	118+0	118
16	9436	118+9, ?124+0	?126
Oct. 1	9451	Not seen<118	
1885			
Mar. 9	9610	110+1	111
11	9612	110+3, 118−3	114
27	9628	Not seen<118	
Apr. 1	9633	<118+3	
8	9640	=13·3	
17	9649	Not seen<118+6	
18	9650	<13·0	
19	9651	Invis.<13·2	
May 7	9669	About 13·2	
11	9673	122+7	129
16	9678	122−1	121
June 1	9694	96+9, 105−5	102
9	9702	96+2, 105−9	97
12	9705	96+2	98
July 4	9727	96+2	98
9	9732	96+1, 105−5	98
26	9749	96+7, 105−3, 110−4	104
Aug. 14	9768	105−2, 110−4	104
Sept. 3	9788	118+4	122
13	9798	118+8, 122+2	125
27	9812	122+3	125
1886			
Feb. 14	9952	118−3	115
26	9964	122+3	125
Mar. 8	9974	Not seen<122+3	
29	9995	13·4 est.	
	241+		
Apr. 6	0003	122+6, min. vis. −6	128
26	0023	118−2	116
May 21	0048	110−2	108
29	0056	96+7, 105−2, 110−7	103
June 26	0084	96−5	91
30	0088	96−6	90
Sept. 14	0164	<118+3	
1887			
Feb. 5	0308	118−4, 110+3	114
18	0321	118+3	121

1884 July 12, low, hazy, and ☽. Aug. 6, hazy. Aug. 14, low.

Observations by J. Baxendell, junior.

Date.	J.D.	Mag.	Date.	J.D.	Mag.	Date.	J.D.	Mag.
1887			1888			1889		
Mar. 29	0360	Say 135	Mar. 18	0715	125	May 31	1154	97
Apr. 10	0372	Abt. 127	31	0728	119	June 16	1170	103
11	0373	126	May 1	0759	106	July 16	1200	124
14	0376	123	15	0773	Abt. 101	Aug. 29	1244	Abt. 127
17	0379	120	20	0778	98	Sept. 30	1276	105
23	0385	116	June 18	0807	105			
May 7	0399	Abt. 103	Aug. 2	0852	130	1891		
9	0401	102	Oct. 3	0914	? 109	Mar. 11	1803	113
13	0405	? 101	30	0941	? 106	29	1821	112
16	0408	99				Apr. 7	1830	? 111
31	0423	95	1889			17	1840	106
June 10	0433	95	Feb. 20	1054	Suspected abt. 129	22	1845	107
20	0443	Abt. 95	Mar. 10	1072	? 123	23	1846	107
July 14	0467	108	27	1089	? 108	May 4	1857	105
15	0468	106	31	1093	105	11	1864	103
31	0484	115	Apr. 18	1111	104	17	1870	102
Aug. 14	0498	122	May 1	1124	104	25	1878	108
Sept. 24	0539	Not seen	18	1141	? 97	31	1884	112
			25	1148	98	June 10	1894	122

As these observations seemed to suggest a period of about 176 days, they were tabulated and dealt with in the usual manner, with an assumed period of that length. The magnitude at maximum seems to be usually between 9·0 and 9·8; but in the last period (No. XXIV.) observed by Mr. Baxendell, junior, it appears to be about 10·2. There are very few observations near minimum, but the star seems to decrease to at least 13·0.

The results of the tabulation are as follows:—

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)	(11.)	(12.)
A Mean (B. senior) .	107_{12}	99_{10}	95_{14}	93_{16}	100_{28}	108_{17}	119_{28}	127_{9}	130_{6}	130_{2}	125_{7}	118_{8}
B ,, (B. junior) .	104_{3}	103_{4}	96_{4}	95_{1}	105_{1}	107_{2}	115_{1}	127_{2}	...	$?129_{1}$	125_{3}	117_{6}

"A" consists of Periods I. to XV. (8) (omitting X.); "B" of Periods XV. (10) to XXI. (omitting XX.). There is no sign of any progressive movement of maximum or minimum; but there is an appearance of a later maximum than usual in Periods X. and XX., so these have been omitted in taking the means. There is a still stronger appearance of advance in Period XXIV. The figures of "A" form a pretty good Light Curve, with which the individual observations have been compared in the usual way.

The maximum is rather sharp, at about 49 days after the arbitrary zero point, and the minimum is much flatter, about 83 days after maximum, so that the fall is a little sharper than the

rise. These positions are, however, open to a correction of several days.

The details of corrections to epoch are not given in full for the separate "portions," to save printing; but the results are shown in the following table. The corrections have been taken sometimes for maximum and sometimes for minimum, according to the observations available on each side of one or the other. Some of them overlap, of course.

TABLE IV.

Period.	Mean Date. (Max.)	Correction *d.*	Mean Date. (Min.)	Correction *d.*	Period.	Mean Date. (Max.)	Correction *d.*	Mean Date. (Min.)	Correction *d.*
I.	7799	-2_5	7882	$+0_9$	XIII.	9911	...	9994	-1_5
II.	7975	$+1_8$	8058	...	XIV.	0087	...	0170	...
III.	8151	...	8234	-3_9	XV.	0263	...	0346	$+2_7$
IV.	8327	-5_8	8410	...	XVI.	0439	$+1_8$	0522	...
V.	8503	...	8586	-2_5	XVII.	0615	...	0698	...
VI.	8679	-2_3	8762	...	XVIII.	0791	-3_6	0874	-6_4
VII.	8855	...	8938	$+3_5$	XIX.	0967	...	1050	...
VIII.	9031	$+2_2$	9114	...	XX.	1143	-2_7	1226	-1_5
IX.	9207	...	9290	$+3_8$	XXI.	1319	...	1402	...
X.	9383	$+4_8$	9466	...	XXII.	1495	...	1578	...
XI.	9559	...	9642	$+7_6$	XXIII.	1661	...	1754	...
XII.	9735	$+2_9$	9818	...	XXIV.	1837	$+7_6$	1930	...

Portions 4 and 9 have not been used, as being so close to maximum and minimum as to be misleading. The subscript figures give the number of "portions" used for each correction.

It will be seen from this table: (1) that the corrections to epoch are almost negligible, so that the period would seem to be practically uniform during this series; (2) that the suggestion of a slight advance of the epoch about Period X. is upheld by the calculated figures for Periods IX. to XII.; (3) that the same suggestion in regard to Period XX. is *not* upheld (the appearance rests, in fact, on one rather doubtful observation only); (4) that the appearance of a very considerable advance of epoch in Period XXIV. is only very partially supported. But the observations in this period give such an abnormally faint magnitude about maximum that the results may be untrustworthy. A wave-like variation of epoch extending over about thirteen periods could be deduced, but the data are quite insufficient for anything approaching to proof. The maxima would be at about Periods XI. and XXIV., and the minima at about IV.–V. and XVII.–XVIII.

When the curve is analysed, the coefficients divided by the range and multiplied by 6, and the phases brought to the maximum for the principal wave, we get the expression:

$$3{\cdot}0 \cos(\theta - 180^\circ) + 0{\cdot}11 \cos(2\theta - 214^\circ) + 0{\cdot}06 \cos(3\theta - 348^\circ).$$

Now these phases do not at all fit into either of the Rev. T. E. R. Phillips' groups of variable stars (see *B.A. Journ.*, Oct. 1916). He finds for Group I. a nearly constant value of ϕ_3 near 200° ; the value 348° is quite irreconcilable with this. As regards Group II., the value $\phi_2 = 214°$ is considerably beyond the last star in his list, which has $\phi_2 = 197°$; and the value of ϕ_3 deduced from his formula

$$\phi_3 = 1{\cdot}67\phi_2 - 126°,$$

should be 230° instead of 348°.

Three alternative explanations may be suggested. (1) This curve, being obtained from rather few observations and periods, may be untrustworthy, especially as the coefficients of the second and third wave are very small, so that comparatively slight changes in the curve might alter their phases radically. (2) The star may belong to a *third* group, represented by a line running nearly parallel to that of Group I., but with ϕ_3 approximating to 350° instead of 200°. V Cygni$_2$, T Hydræ, S Lyræ, R Persei, and T Ursæ Majoris$_2$ might also belong to the same group. (3) The Light Curve may be really of an anomalous character.

A list of maxima and minima given in *H.A.*, **55**, suggested application to Mr. J. A. Parkhurst for possible further observations. Under date 1917 November 20, he promises attention to the star at the earliest possible moment.

No. 26, *U Canis Minoris* (2735 *Chandler*).

$7^h\ 33^m\ 32^s$	$+8°\ 42'{\cdot}1$	(1855·0)
7 35 55	+8 36 ·8	(1900·0)

Identification of Comparison Stars.—There are eight sketches of these, in which the designations differ greatly, but as a rule it is easy to identify them one with another. The chief difficulty occurred in regard to the circumstance that during the first six months Baxendell always used *numbers* for the comparison stars, and that, of these numbers, 5 and 7 only were ever marked in the sketches. The numbers used were 1, 2, 3, 4, 5, 7, and "6 of n. sq." The latter expression gave the necessary clue, and it was found that this star was the 6th (in order of R.A.) within the square of Argelander's Charts next (northward) to that in which the variable is found. The other numbers were then found to fit the first 5, and the 7th, of the stars shown in the variable's own square, reckoning them in the same way.

In examining references it was found that there are a number of errors in the places given in *H.A.*, **57**, 238. The R.A.'s of stars *b* to *m* should all be increased by 20 sec., and that of star *h* further by 1 min. ; the declination of star *b* should be $+8°\ 37'{\cdot}7$ instead of $+8°\ 33'{\cdot}4$, and of star *l* should be $+8°\ 39'{\cdot}2$ instead of $+8°\ 32'{\cdot}0$.

TABLE V.

Baxendell's Comparison Stars for U Can. Min.

Used 1879–80.	Baxendell. 1880. Oct. 10.	1880. Oct. 29.	1881. Dec. 10.	1882. Feb. 12.	1883. Jan. 30.	1884. Mar. 23.	1884. Apr. 12.	1884. Dec. 15.	A.S.V. No.	A.S.V. Grade.	Harvard. Letter.	Harvard. Mag.	Adopted Mag.
7	7	7	7	7	*a*	*y**	7	*a*	1	0	*a*	8·50	·85
2	...	...	...	...	...	...	...	...	2	3	...	...	88
5	5	5	...	5	*b*	5	5	*b*	3	7	*b*	9·00	90
4	...	...	...	...	...	...	...	...	5	12	...	...	95
6 of n. sq.	...	...	...	...	...	...	...	...	10	21	...	...	101
1	...	...	...	...	...	...	...	...	13	24	*e*	10·43	104
3	...	...	...	...	...	...	...	...	14	26	...	...	105
...	...	*x*	...	*l*	*w*	...	...	*c*	17	28	*f*	10·70	107
...	...	...	...	...	*v*	...	...	...	23	35	*g*	11·20	112
...	*m*	*y*	*m*	*m*	*x*	*y*	*x*	*d*	30	48	...	...	117
...	...	(*z*)	*n*	(*n*)	*y*	*x*	*y*	*e*	55	72	*l*	12·40	124

* No doubt a slip for 7.

TABLE VI.

Baxendell's Differences between his Comparison Stars.

Years.	90–85.	90–88.	88–85.	95–90.	107–90.	101–90.	101–95.	95–85.	117–107.	124–117.
1879	$4\cdot5_{11}$	$0\cdot5_{7}$	$3\cdot6_{6}$	$6\cdot7_{3}$	...	$11\cdot2_{3}$	$5\cdot0_{2}$	$10\cdot2_{2}$	...	...
1880	$5\cdot5_{31}$	$1\cdot5_{2}$	$2\cdot5_{1}$	$6\cdot6_{33}$	...	$12\cdot0_{14}$	$5\cdot6_{17}$	$10\cdot7_{20}$	$6\cdot0_{1}$	...
1881	$6\cdot1_{12}$	...	...	$4\cdot2_{12}$	...	...	...	$9\cdot3_{6}$	$11\cdot5_{1}$	$8\cdot0_{1}$
1882	$7\cdot2_{10}$	...	...	$7\cdot0_{2}$	$19\cdot8_{13}$	...	...	...	$7\cdot0_{4}$	$9\cdot5_{2}$
1883–4	$3\cdot9_{6}$	...	...	$8\cdot0_{2}$	$17\cdot5_{2}$	...	...	$11\cdot0_{1}$	$10\cdot8_{9}$	$7\cdot1_{5}$
1885–7	$4\cdot8_{19}$	...	...	...	$16\cdot4_{4}$	...	...	...	$11\cdot0_{1}$	...
Mean	5·4	0·7	3 4	6·1	18·8	11·9	5·6	10·4	9·6	7·8
Reduced Means	4·9	0·6	3·0	5·6	17·0	11·0	5·3	9·5	8·8	7·0
No. of Obs.	89	9	7	52	19	16	19	29	16	8

Only half the usual amount of reduction has been applied, as the intervals seem to be less inflated than usual.

The intervals between the stars 90 and 85 seem to show a progressive increase during the first four years, and Baxendell suspected the former of varying. There are a certain number of comparisons which are not given in Table VI., either because they are very few, or because the stars concerned are scarcely ever used for comparison with the variable.

The telescope used was E80, except that on 1885 Feb. 28 power 125 was used.

TABLE VII.

Baxendell's Observations of U Canis Minoris.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1879	240+		
Nov. 25	7679	90+1, 88+1, 85+2, 95−5	89
27	7681	85+3, 90+0, 88+0	89
28	7682	85+4, 90+0, 95−6	89
29	7683	90+1, 85+4	90
30	7684	85+3, 90−1	88
Dec. 3	7687	85+6, 90+2, 88+2	91
4	7688	85+5, 90+2, 88+2	91
6	7690	85+6, 90+2	92
22	7706	85+9, 90+5	94
23	7707	85+11, 90+7, 95+2, 101−2, 88+9	97
24	7708	85+11, 90+8, 88+9	97
26	7710	85+11, 90+9, 88+9, 95+3, 101−3	97
1880			
Jan. 2	7717	95+5, 101−2, 85+11, 90+8, 88+9	98
18	7733	85+12, 90+9, 95+5	99
19	7734	"Unchanged"	99
20	7735	90+9, 101−2, 85+12, 95+5	99
22	7737	95+0, 101−3	96
26	7741	95−1, 85+9, 90+6, 101−5	95
28	7743	90+6, 101−6, 95+0, 85+10	95
1880	240+		
Jan. 29	7744	"Same as last night"	95
31	7746	85+9, 95−1, 90+5, 101 3	95
Feb. 1	7747	85+9, 90+5, 101−4, 95−1	95
3	7749	90+8, 95+1, 101−4	97
4	7750	90+7, 101−6, 85+9, 95+3	96
8	7754	85+7, 95−2, 90+3, 101−9	92
10	7756	85+11, 95−2, 90+7	95
14	7760	90+6, 95−1	95
20	7766	90+6, 95−2, 85+9	94
24	7770	90+5, 95−3	94
Mar. 7	7782	95−2	93
10	7785	90+6, 95−1	95
13	7788	85+11, 95−1, 90+5	95
14	7789	95−2	93
16	7791	95−2	93
18	7793	95+0, 85+11, *90+6	96
19	7794	95−1	94
24	7799	85+11, 95−1, 90+6	95
27	7802	95−1	94
Apr. 1	7807	85+11, 90+8, 95+2	97
2	7808	95+2, 90+9	98
4	7810	95+2, 90+8, 85+12	97
8	7814	85+11, 90+5, 95+1	96

* "5 must be slightly variable."

TABLE VII.—*Baxendell's Observations of U Canis Minoris*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1880	240+		
Apr. 9	7815	95+1	96
11	7817	85+11, 90+7, 95+1	96
16	7822	95+2, 90+9	98
17	7823	95+0, 90+7	96
19	7825	95+2, 90+7	97
22	7828	95+1, 90+8	97
24	7830	95+2, 90+9	98
29	7835	95+3, 101+0	100
30	7836	95+4, 85+11	98
May 1	7837	95+4	99
3	7839	95+5, 90+10, 101+0	100
4	7840	90+8, 95+5, 101−1	99
6	7842	95+5, 101+0, 90+8, 85+14	100
7	7843	95+5	100
9	7845	95+5, 90+7	98
12	7848	95+5, 101−1	100
Oct. 10	7999	117+1	118
29	8018	107−2, 117−7	108
Nov. 19	8039	101−1, 107−10	98
26	8046	101−3, 95+6, *?107−11	?98
Dec. 1	8051	101−2, "=9·7"	99
11	8061	90+10, 95−1, 101−6, "=9·5"	96
24	8074	90+2, 85+8	92
25	8075	90+2	92
30	8080	85+7, 90+2	92
1881			
Jan. 5	8086	90+2, 85+8	92
12	8093	90+6, †?95+3, 85+11	?97
Feb. 6	8118	85+11, 90+4, †?95+1	95
23	8135	90+10, 95+0, 101−6	97
28	8140	90+11, 95+4	100
Mar. 31	8171	90+3, 95−2	93
Apr. 1	8172	90+3, 95−2	93
3	8174	85+5, 90−1, 95−4	90
5	8175	90−1, 95−4	90
6	8176	85+5, 90−1, 95−5	90
7	8177	85+5, 90−2, 95−5	89
8	8178	85+4, 90−2	88
17	8188	90−1, 95−4, 85+4	90
May 4	8205	85+1, 90−4	86
7	8208	85+3, 90−4, 95−6	88
12	8213	85+4, 90−4, 95−5	88
Oct. 26	8380	Not seen.	
Nov. 14	8399	124+0	124
17	8402	124+1	125
Dec. 10	8425	117+1	118
12	8427	117+0	117
19	8434	117−6	111
27	8442	107+5, 117−6, 124−12	112
1882			
Feb. 12	8489	90+8, 107−5	100
Mar. 6	8511	90+9, 95+2	98
8	8513	90+9, 107−10, 95+4	98

1880 May 6, very low. May 7, low, haze, and twilight. May 9, low, hazy.

* "*a* of Nov. 19"; probably means *x*. † The query is Baxendell's.

TABLE VII.—*Baxendell's Observations of U Canis Minoris*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1882	240+		
Mar. 12	8517	90+6, 107−6	98
16	8521	90+7, 107−9	98
18	8523	Photo. mag. = 9·4,	
		90+6, 107−8	98
20	8525	90+7, 107−10	97
22	8527	90+7, 107−11	96
Apr. 3	8539	*90+7	?97
6	8542	90+6, 107−11	96
8	8544	90+6, 107−11	96
10	8546	90+9, †?107−9	98
20	8556	90+6, 107−11	96
May 6	8572	90+4, 107−17	?92
6	8572	90+4, 107−21	?90
12	8578	90+3, 107−17	?91
		(or more)	
14	8580	90+5	95
Oct. 28	8747	107+3	110
1883			
Jan. 30	8841	117−1, 124−6	117
Feb. 22	8864	107+6, 117−7	112
23	8865	107+6, 117−6	112
Mar. 3	8873	107+10, 117−3	116
5	8875	117−3, 107+0	110
12	8882	107+0, 117−9	108
24	8894	107−5	102
26	8896	107−3	104
Apr. 1	8902	107−7	100
8	8909	107−7	100
1884			
Feb. 2	9209	About min. vis. − 2	?130
11	9218	Invisible; hazy	
		and ☽	
24	9231	124+3	127

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1884	240+		
Feb. 25	9232	124+4	128
Mar. 16	9252	124−2	122
23	9259	124−4, 117−1	118
31	9267	‡[90+6]	[96]?113
		?107+6	
Apr. 9	9276	124−3	121
12	9279	117−1, 124−7	116
Nov. 14	9495	85+6, 90+2,	91
		95−5	
20	9501	85+6, 90+2	92
24	9505	90+7, 95+1	96
Dec. 10	9521	85+6, 90+3	92
15	9526	90+9, 107−8	99
20	9531	90+7, 107−7	98
1885			
Jan. 5	9547	107−2	105
7	9550	107+0	107
12	9555	107+0	107
Feb. 3	9576	117−2	115
7	9580	117+0	117
19	9592	117+1	118
22	9595	117−1	116
28	9601	117+0	117
Mar. 6	9607	117+6, 124+2	124
9	9610	117+6, 124+0	124
17	9618	124+3	127§
Apr. 2	9634	124+1	125§
8	9640	124+4	128
17	9649	124+4	128
19	9651	124+5	129
May 11	9673	Invis. <117	
Nov. 17	9863	85−2, 90−6	84
Dec. 1	9877	85+0, 90−5	85

1882 Apr. 3, low and hazy. May 6, "Has 5 diminished?"
1882 May 6, "Has *l* [107] diminished?" 1883 Mar. 5, "Has *w* [107] changed?"
1884 Feb. 2, "Min. vis. = 13·3." 1885 Feb. 28, ☽ and haze.

* The entry is "7," but it seems clear it should be "5."
† The entry is "11?"; no doubt "11" should be "*l*."
‡ Entry is "*b*"; should probably be "*l*."
§ Baxendell, junior, made it fainter Apr. 2 than Mar 17.

TABLE VII.—*Baxendell's Observations of U Canis Minoris*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1886	240+		
Jan. 4	9911	85+0, 90−4	86
5	9912	85−3, 90−4	*84
11	9918	85−1, 90−3	86
29	9936	85−3, 90−2	88
Feb. 1	9939	85+6, 90+0	90
4	9942	85+5, 90+1	90
14	9952	85+7, 90+2	92
23	9961	90+6	96
25	9963	90+6	96
Mar. 3	9969	90+6, 107−7	98
6	9972	90+7, 107−6	99
10	9976	90+11, 107−5	102
12	9978	90+10, 107−6	100
29	9995	107−1	106
	241+		
Apr. 9	0006	107+5, 117−6	112
26	0023	117+4	121
Nov. 17	0228	90+5	95
Nov. 30	0241	85+9, 90+3	94
Dec. 4	0245	90+5	95
16	0257	90−1, 85+6	90
29	0270	85+6, 90−1	90
1887			
Jan. 20	0292	90+5	?95
26	0298	85+5, 90−2	89
Feb. 5	0308	85+0, 90−7	84
9	0312	85+0	85
10	0313	85+0	85
11	0314	85+0	85
14	0317	85+1	84
18	0321	85+0	85
25	0328	85+3	88
26	0329	85+4	89
27	0330	85+3	88
28	0331	85+1	86
Mar. 3	0334	85+1	86

1887 Jan. 20, "Sky very thick."

* Baxendell, junior, makes it just *fainter* than on the 4th and 11th.

Later Observations by J. Baxendell, junior.

Date.	J.D.	Deduced Mag.
1887 Mar. 12	0343	84½
15	0346	85½
23	0354	85
28	0359	88½
Apr. 10	0372	92
11	0373	92
14	0376	?92½*
17	0379	93
25	0387	94
May 7	0399	?99†
9	0401	Abt. 101
Dec. 13	0619	88
21	0627	86
1888 Feb. 14	0682	91½
15	0683	94
Mar. 17	0714	92
26	0723	Abt. 91
Apr. 2	0730	91
Dec. 28	1000	98
1889 Jan. 18	1021	91
Feb. 3	1037	89
Mar. 10	1072	92
26	1088	92
1891 Mar. 11	1803	108
29	1821	104
Apr. 11	1834	101
22	1845	100

* "5" is less than usual.

† Uncertain, low and full ?.

As the period seemed on inspection of the observations to be in the neighbourhood of 420 days, the observations were tabulated, in the usual way, for an assumed period of that length, 24 "portions" being taken instead of 12, in order to obtain clearer evidence in regard to a secondary maximum and minimum which seemed to be indicated. As the results showed an apparent forward movement of the principal maximum, periods of 426, 423, and 424 days were successively tried, and the last seemed fairly satisfactory. The later observations of Mr. Baxendell, junior, were included, but 0·1 mag. was added to each, as it was found that when both the observers recorded observations of this star on the same occasion, there was almost constantly that difference between them. Table VIII. gives the weighted means for the 24 portions, the number of periods for each, and the curve as drawn, in which, as will be seen, one position had to be slightly modified for the sake of smoothness. Analysis of this curve gives the expression (in units of 0·1 mag.)

$$16{\cdot}94 \cos(\theta - 249^\circ) + 6{\cdot}60 \cos(2\theta - 123^\circ) + 0{\cdot}82 \cos(3\theta - 68^\circ),$$

which becomes, when divided by the range, multiplied by 6, and brought to the maximum phase of the principal wave,

$$2{\cdot}54 \cos(\theta - 180^\circ) + 0{\cdot}99 \cos(2\theta - 345^\circ) + 0{\cdot}12 \cos(3\theta - 221^\circ).$$

This fits well into Phillips' Group I. (*Jour. B.A.A.*, **27**, 6, October 1916), except that the second coefficient is remarkably large, which is obviously due to the marked secondary maxima and dips. The curve resembles that of R Aurigæ.

TABLE VIII.

Mean Light Curve of U Canis Minoris.

(The unit is 0·1 magnitude.)

Portion	1	2	3	4	5	6	7	8	9	10	11	12
Weighted Mean of Observations	94	94	94	95	95	92½	90	90	91	93	96	100½
No. of Periods	3	5	5	5	3	5	5	4	4	4	4	4
Curve	94	94	94	95	95	92½	90	90	91	93	96	100½
Portion	13	14	15	16	17	18	19	20	21	22	23	24
Weighted Mean of Observations	106	114	119	124½	129	128	124	118	111	105	100	97
No. of Periods	1	2	3	1	2	2	2	5	5	3	3	4
Curve	106	113	119	124½	129	128	124	118	111	105	100	97

It is unlucky that Baxendell was never able to observe a minimum quite certainly; but he perhaps did just catch one at the beginning of his observations in February 1884, and another at the end of those in the spring of 1885. The supposed minima ascribed

to him in *H.A.*, **55**, for 07986 and 08402, are found to be placed much too late, the minimum on each occasion having really passed a good while before he began observing. Only two primary maxima are well observed, but in some other cases the date can be inferred approximately. In the case of the minima it is generally fairly easy to fix the approximate date in this way, even when there are no observations very near it, as the variations seem to be less irregular near minimum than near maximum, and, owing to the great length of the period, a long gap is less serious than in ordinary cases.

Table IX. gives the mean dates for primary maxima and minima, and the limits for secondary maxima as indicated by the curve, and compares them with the most probable "observed" dates = O.

TABLE IX.

Maxima and Minima of U Canis Minoris.

Period.	M. (Sec. Max.)	O. (Sec. Max.)	M. (Max.)	O. (Max.)	O−M.	M. (Min.)	O. (Min.)	O−M.
O.	7654–7699	? 7680 *	7773	*7770* †	−3	7952	*7952*	0
I.	8078–8123	8080 and 8120 †	8197	8204 *	+7	8376	8374	−2
II.	8502–8547	? 8545 † and ? 8566	8621	...	...	8800	8796	−4
III.	8926–8971	...	9045	...	...	9224	*9220*	−4
IV.	9350–9395	...	9469	...	...	9648	*9650*	+2
V.	9774–9819	...	9893	9890 *	−3	0072	0078	+6
VI.	0198–0243	? 0260	0317	*0315* *	−2	0495	? 0496	? 0
VII.	0622–0667	? 0640 *	...	...	...	0920	...	...
VIII.	1046–1091	? 1048	...	...	...	1344	...	...
IX.	1470–1515	...	...	...	...	1768	? ? 1750	? −18

* These are very bright. † These are very faint.

The late secondary maximum of 8566 rests on three doubtful and inconsistent observations, and that of 0260 rests on two observations only.

The dates in italics are the best authenticated, and those with queries are very doubtful, but in even the best instances there is a possible error of 6 or 8 days. The date for Min. IX. (O.) might easily be earlier.

Harvard (vol. **55**) gives maxima and minima observed by various people, including Baxendell. It gives two of Baxendell's maxima as 7770 and 8200, and his secondary one, 8077; and also three minima at 7986, 8402, and 9651, the first two of which are wrong, as already mentioned. As is shown in Table X., a period of 424 days for the first 7 periods, followed by one of 412 days for the next 4, 400 for the next 8, 412 again for the next 4, and 424 again after that, would suit all the observed dates fairly well, allowing a reasonable margin for doubtful ones. But 5 of the

observed dates of secondary maxima (out of 15) are later than the limits shown by the mean curve. This seems to show that those limits ought to be extended to within about 55 days of the primary maximum, thus allowing for a third secondary rise before the primary one in some cases. There are slight indications of all three in two of Baxendell's periods. But Schmidt's date 08147 is contradicted by Baxendell's observations, and others may not be very certain.

TABLE X.

Maxima and Minima of U Canis Minoris.

		Maxima.						Minima.		
		Secondary.			Primary.					
	Period.	M.	O.	Observer.	M.	O.	Observer.	M.	O.	Observer.
424d.	O.	7654–99	7680	Bax.	7773	7770 (7793)	Bax. Schmidt.	7952	7952	Bax.
	I.	8078–123	8080 8120 (8147)	,, Schmidt	8197	8204	Bax.	8376	8374	,,
	II.	8502–47	8545 8576	Bax.	8621	..	..	8800	8796 8794	,, Schmidt
	III.	8926–71	..	..	9045	..	..	9224	9220 9208	Bax. Knott
	IV.	9350–95	..	..	9469	..	..	9648	9650	Bax.
	V.	9774–819	..	..	9893	9890	Bax.	0072	0078	,,
	VI.	0198–243	0260	Bax.	0317	0315 0305	,, Knott	0496	0496	Bax., J.
412d.										
	VII.	0610–55	0640 0646	Bax., J. Knott	0720	..	..	....	..	..
	VIII.	1022–67	1048 1031	Bax., J. Knott	1141	..	..	1320	..	..
	IX.	1434–79	..	..	1553	..	..	1732	?? 1750	Bax., J.
	X.	1846–91	..	..	1965	..	..	2144	2148	Knott
400d.										
	XI.	2246–91	..	..	2365	..	..	2544	2539 (2564)	Knott H.M.P.
	XII.	2646–91	..	..	2765	..	..	2944	(2946)	,,
	XIII.	3046–91	..	..	3165	..	..	3344	(3325)	,,
	XVII.	4646–91	4692	H.M.P.	4765	4761	H.M.P.	4944	..	,,
	XVIII.	5046–91	..	..	5165	..	..	5344	5341	Esch
412d.										
	XIX.	5458–503	5521	H.M.P.	5577	..	..	5756	(5720)	Esch
	XX.	5870–915	..	..	5989	..	..	6168	..	,,
	XXI.	6282–327	..	..	6401	..	..	6580	..	..
	XXII.	6694–739	6756	H.C.O.	6813	..	..	6992	..	..
424d.										
	XXIII.	7118–63	7151	Hartwig	7237	7220 7277	H.C.O. Whiteside	7416	..	..
	XXIV.	7542–87	..	..	7661	7640	H.C.O.	7840	..	..

Though it may be considered unlikely that the period actually undergoes the above sudden and abrupt changes, they may perhaps fairly represent (in skeleton form) a more smooth and gradual process of variation, the exact nature of which cannot at present be determined.

No. 27, χ *Cygni* (7120 *Chandler*).

$19^h\ 44^m\ 59^s{\cdot}4 + 32^\circ\ 33'{\cdot}0$ (1855·0)
19 46 44 + 32 39 ·7 (1900·0)

Identification of Comparison Stars.—Baxendell made one chart and twenty-two sketches, and he also sometimes used a sketch by Kirch (1714). The identifications for his chart and for most of the sketches present no difficulties, but the sketch of 1857 July 31, for faint stars, proved very puzzling, as it contains a good many stars, and is not drawn to scale. Some of the stars marked on it have not been identified, but all which were used for comparison with the variable have been so with reasonable certainty. Another puzzle concerned a star which Baxendell called "Kirch's *k*." When a copy of Kirch's sketch was obtained, it was found that there was no *k*, but only the letters *a* to *h*, inclusive. From internal evidence there seems to be no doubt that Kirch's *h* is the star meant, and it was probably due to some copyist's mistake that Baxendell called it *k*. For several years he called the variable "var. in Swan's Neck," and gave the name χ to the star (51). Afterwards he called the variable "var. χ," and the other "χ" or "old χ"; and in 1863 he began to call the latter *a* and the var. χ. But the different names overlap to some extent. As such a large number of comparison stars were used, they have been divided into three tables, one for the naked-eye stars, and two for the fainter ones, one star being included in the first two. To save printing, sketches which are in complete agreement have not been given separately from one another, although in some cases not all the letters are given in each sketch. Very valuable help was received through Mr. J. Baxendell, junior, from Mr. Wesley in connection with Kirch's sketch. The "Harvard" values in brackets in Tables (*b*) and (*c*) are obtained from the A.S.V. Grades by the curve given in *H.A.*, 37, 200.

[Table

Table XI.

Baxendell's Comparison Stars.

(*a*) *Naked-eye Stars.*

Usual Names.	Kirch, 1714.	Baxendell. Sketch, 1840 Sept. 3.	Chart, 1863 Oct. 13.	Sketch, 1874 Nov. 11.	R.H.P.	Adopted Mag.
η Cyg.	η	η	...	...	4·03	41
39 ,,	...	...	...	...	4·60	46
ζ Lyr.	...	...	...	...	(Double)	47
ϕ Cyg.	ϕ	ϕ	...	...	4·79	48
8 ,,	...	...	...	...	4·85	49
2 ,,	...	...	...	...	4·86	49 (2)
28 ,,	b	b^2	...	...	4·82	...
29 ,,	...	b^3	...	..	4·98	50
χ^1 ,,	* ב	χ	a	Old χ	5·03	51
9 ,,	...	...	...	...	5·42	54

* The Hebrew letter Beth.

(*b*) *Magnitudes* 5·1 *to* 10·8.

Kirch 1714.	1850 May 14 and 1856 Oct. 19 (2).	1851 July 17 to 1856 Sept. 19 and 1858 Apr. 4 (5).	1857 Feb. 11.	1857 Sept. 19 and 1863 June 22 and 30. (3).	1858 July 18.	1862 Oct. 29.	1863 July 3.	Chart, 1863 Oct. 13.	1878 May 11.	A.S.V. No.	A.S.V. Grade.	Harvard.	Adopted Mag.
ב	...	...	...	...	...	...	...	*a*	...	1	...	5·03	51
...	...	...	...	...	...	...	...	...	...	...	...	* 5·95	59
e	Ll 37783	...	...	...	...	...	...	*b*	...	3	...	*l* 6·40	64
d	37692	...	...	...	...	...	...	*c*	...	2	...	*k* 6·09	61
...	..	...	...	...	...	...	...	*d*	...	4	0	(6·76)	68
a	*a*	*a*	*a*	...	...	...	*a*	*e*	*a*	6	13	*p* 7·53	75
b	*b*	*b*	*b*	...	*b*	...	*b*	*f*	*b*	7	23	*r* 8·11	81
† $\hbar$	...	*m*	*m*	...	...	...	*m*	μ	...	13	36	*t* 8·68 (8·87)	88
g	...	*g*	...	*g*	*g*	*g*	...	*g*	...	20	46	(9·39)	92
...	..	...	...	λ	δ	λ	...	æ	...	27	53	*y* 9·88	99
...	...	...	...	δ	λ	æ	...	*h*	...	34	62	(10·07)	100
..	...	...	...	..	...	...	...	*k*	...	55	86	...	..
...	...	...	...	...	...	...	...	*l*	...	51	80	α 10·52	105
...	...	. .	...	. .	...	...	...	*m*	...	59	87	β 10·79	108
..	.	*v*	...	...	...	...	...	...	...	11	32	(8·61)	86
..	...	*w*	*n*	...	...	...	...	...	...	14	39	(9·03)	90
..	..	*x*	...	...	...	...	...	...	...	26	51	(9·64)	96

* Called Ll 37584, but not shown in any sketch.
† Called "Kirch's *k*."

(*c*) *Magnitudes* 11·0 *to* 12·5.

1857 July 19.	1857 July 31.	1862 Nov. 24.	1863 May 17.	1863 June 12.	Chart, 1863 Oct. 13.	A.S.V. No.	A.S.V. Grade.	Harvard.	Adopted Mag.
b	*c*	*a*	...	*a*	...	62	89	γ 11·00	110
c	*b*	*b*	*a*	*b*	...	75	106	(11·50)	112
d	*d*	...	...	...	...	64	92	(11·09)	111
...	...	...	...	...	*n*	67	98	δ 11·33	113
...	*p*	...	...	...	*o*	74	104	ϵ 11·65 (11·44)	114
...	*w*	...	...	...	...	76	107	(11·52)	115
...	*v*	...	...	...	...	87	128	ζ 11·92	119
...	*x*	...	...	...	...	98	150	θ 12·45	124
...	*y*	...	...	...	...	101	152	(12·48)	125

The earlier observations were recorded in the notation described in *M.N.*, 76, 171, and they have been interpreted by the table on that page, using columns B and C, with a compromise between them when the magnitude was very near 6·5.

TABLE XII.

Baxendell's Differences between Comparison Stars.

(*a*) *Old Notation* (*unit* 0·1 *mag.*).

Years.	51–49.	49–48.	51–48.	64–51.	64–61.	75–64.	81–75.	88–81.	92–81.	92–90.	92–88.
1840–8	...	...	$3\cdot0_2$	...	...	...	...	...	...	...	...
1850–3	...	...	...	...	...	$11\cdot7_9$	$7\cdot4_{10}$	...	$10\cdot3_3$	...	$5\cdot0_3$
1854–7	$2\cdot8_{17}$	$1\cdot5_{15}$	$3\cdot8_8$	$11\cdot5_4$	$2\cdot5_2$	$13\cdot0_4$	$7\cdot5_2$	$10\cdot5_2$	$12\cdot0_1$	$1\cdot6_{11}$	...
Mean	$2\cdot8_{17}$	$1\cdot5_{15}$	$3\cdot6_{10}$	$11\cdot5_4$	$2\cdot5_2$	$12\cdot0_{13}$	$7\cdot4_{12}$	$10\cdot5_2$	$10\cdot8_4$	$1\cdot6_{11}$	$5\cdot0_3$

(*b*) *New Notation* (*unit Baxendell's step*).

Years.	51–49.	49–41.	61–51.	64–51.	64–61.	75–64.	81–75.	88–81.	92–81.	75–61.	92–88.	100–99	100–92.
1857–61	...	$4\cdot8_6$	...	$9\cdot7_3$	...	$9\cdot3_6$	$2\cdot2_3$	$9\cdot0_3$	$10\cdot4_6$	...	$1\cdot6_7$	$0\cdot25_4$	$5\cdot5_4$
1862–69	$3\cdot6_8$	...	$10\cdot0_2$	$12\cdot2_5$	$1\cdot8_9$	$10\cdot8_3$	$5\cdot3_8$	...	$7\cdot7_3$	$7\cdot9_7$	$7\cdot0_1$	$3\cdot0_1$	$7\cdot0_2$
1879–87	...	...	$8\cdot1_{10}$	$6\cdot9_5$	$0\,6_6$	...	$4\cdot7_3$	...	$11\cdot4_4$	$15\cdot0_1$	...	...	$11\cdot4_4$
Mean	$3\cdot6_8$	$4\cdot8_6$	$8\cdot4_{12}$	$9\cdot6_{13}$	$1\cdot3_{15}$	$9\cdot8_9$	$4\cdot5_{14}$	$9\cdot0_3$	$10\cdot1_{13}$	$8\cdot8_8$	$2\cdot3_8$	$0\cdot8_5$	$8\cdot2_{10}$

There are great variations in some of these intervals, and it is very probable that the star *b* of the chart (64) is variable—Baxendell sometimes thought it brighter than *c* (61)—and either *æ* (99) or *h* (100) would also seem to be variable, as sometimes one and sometimes the other appeared the brighter; also *g* (92) shows suspicious signs of variation.

Baxendell observed with the naked eye from 1840 to 1848 Nov. 14; 1853 June 30 to Aug. 18; 1854 Aug. 28 to Sept. 27; 1855 Sept. 18 to Nov. 3; 1856 Oct. 27 to Dec. 3; 1857 Dec. 19 to 1858 Jan. 20; 1862 June 17 and 28, July 4 (second observation), July 12 to 19 (first observation); 1863 Aug. 5 and 24, and Sept. 4 to 19; 1864 Sept. 27 to Oct. 9, Oct. 31 and Nov. 5:

except on 1853 July 7 and Aug. 18 (second observation in each case); 30 (*a*) was used on these two occasions, and on nearly all dates not already mentioned from 1850 to 1856 (inclusive); and on 1857 Jan. 24 to Feb. 11, and Dec. 7; 1858 Jan. 30, Apr. 1 and 9 (second observation) and June 21. But R (7) 40 was used 1850 May 20 (second observation) and July 13; 1854, July 3 and 19; 1858 Apr. 9 (first observation), Apr. 23, May 3, June 4 and 13, and July 6 and 18: R (7) 39, 1863 Aug. 15. R (13) 81 was used 1858 May 4 to 11; 1861 Apr. 17, May 9, June 14: R (13) 118, 1858 Sept. 21: R (13) 199, 1858 Dec. 2: finder, 1848 Dec. 4 to 1849 Jan. 14; 1855 Nov. 4 and 9; 1856 Dec. 9 to 18; 1864 Oct. 16; 1867 Feb. 1: opera glasses, 1870 June 5; 1874 Nov. 11; and 1875 Dec. 20. C 39 was used 1858 Nov. 5, and in 1860; 1862 June 16, July 4, 19 and 24 (second observations); 1863 Feb. 14, May 8, June 12 and 22, July 8 to Aug. 4, Sept. 28 and 29; 1864 Apr. 25; and 1875 Dec. 5: C 21, 1859 Jan. 23 and Feb. 28: and A 68, 1857 Jan. 13 and June 7 and 24; 1858 July 30, Nov. 6 to 22, Dec. 29; 1859 Sept. 28, Dec. 21; 1861 Apr. 8, May 17 to 29, Aug. 5, Sept. 20, Oct. 28; 1862 Sept. 20, Oct. 29, Nov. 24; 1863 May 17, June 30, Oct. 13 to 30, Nov. and Dec.; and 1864 to 1869, except dates already given for other instruments. A 60 was used 1857 Dec. 4; and T 35, 1857 July to Nov. (inclusive). From 1878, E 80 was used, even when the variable was at its brightest, so far as appears; but sometimes a second observation was taken with the finder, and in these observations χ^1 appeared from 0·2 to 0·4 brighter in proportion to the variable than with the larger instrument. These "finder" observations have not been given.

TABLE XIII.

Observations of χ Cygni.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1840	239+		
Sept. 3	3352	Invis. to naked eye.	
18	3367	,, ,,	
Oct. 25	3404	,, ,,	
1842			
May 2	3958	51−5, <48	?48
5	3961	48−3, 51−5	46
16	3972	46+5, 50−5, 51−8, 48−4	46
June 9	3996	Much <51 or 48	
1844			
Aug. 4	4783	Just vis. much<51	?56
1845	239+		
Sept. 4	5179	Just vis. much<51 or 48	
7	5182	<51	
14	5189	Much >51, >48	?46
15	5190	Very much >51, much >48	?44
17	5192	Nearly =41, between 41 and 46, nearer 41	?43
19	5194	Nearly =41, >46	?42
22	5197	41+0 or brighter	?41
23	5198	>41	
24	5199	>41	

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1845	239+		
Sept. 25	5200	41+0	41
26	5201	? >41	? 41
27	5202	? >41	? 41
30	5205	Certainly >41	? 40
Oct. 13	5218	Much <41	
14	5219	,, ,,	
1848			
Sept. 4	6275	Invis. (naked eye)	
19	6290	,, ,,	
Nov. 14	6346	,, ,,	
Dec. 4	6636	,, (finder)	
13	6375	,, ,,	
17	6379	,, ,,	
20	6382	,, ,,	
28	6390	,, ,,	
1849			
Jan. 2	6395	,, ,,	
11	6404	,, ,,	
14	6407	,, ,,	
Mar. 24	6476	,, (naked eye)	
June 5	6549	,, (30α) <8·0	
1850			
Apr. 27	6875	64+0 or brighter	? 64
May 1	6879	64+0	64
8	6886	64+2	66
12	6890	64+4	68
14	6892	64+4 75−7	68
20	6898	64+7, 75−5	70
,,	,,	64+5, 75−5	70
26	6904	64+7, 75+3	75
29	6907	75+3, 81−6	76
31	6909	75+4, 81−4	78
June 1	6910	75+7, 81−4	80
18	6927	81+8, 88+6, 92−4	90
22	6931	88+4, 92+3	94
July 4	6943	Glimpsed <92	
1850	239+		
July 13	6952	<92, about =99 and 100	? 99
20	6959	Invis.	
Dec. 19	7111	,,	
1851			
Apr. 10	7233	Between 64 and 51	? 58
May 27	7270	64+7, 75−5	70
July 2	7306	81+4	85
4	7308	81+3	84
17	7321	81+8, 92−2	90
21	7325	92+4	96
30	7334	Invis. <92	
1852			
May 19	7628	>64, nearly =51, 51+3	54
July 18	7688	64−2	62
27	7697	64+5, 75−7	68
Aug. 2	7703	64+7, 75−4	71
13	7714	75+4, 81−4	78
Sept. 1	7733	81+3, 92 6	85
1853			
May 12	7986	Invis.	
31	8005	$\frac{81+92}{2}$	86
June 6	8011	$\frac{75+81}{2}$	78
19	8024	64−1	63
30	8035	Glimpsed (naked eye)	
July 7	8042	<51 (vis. naked eye)	
,,	,,	64−6	58
12	8047	Nearly =51	? 54
17	8052	Vis. naked eye, <51	
19	8054	Same	

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1853	239+		
July 22	8057	Same	
28	8063	,,	
Aug. 2	8068	Just vis., fainter	
8	8074	Not vis. (naked eye)	
18	8084	Not vis. (naked eye) =64 or brighter	?64
28	8094	64+7, 75−7	70
Sept. 5	8102	64+11, 75−7	72
1854			
June 15	8385	92−4	88
July 3	8403	75+3, 81−8	76
19	8419	64−2	62
23	8423	51+9, 64−3	60
Aug. 28	8459	Vis. naked eye, abt. =49 (2), >54	?49
Sept. 7	8469	49 (2)+2, <51	?
11	8473	Barely 49 (2)+0	?50
13	8475	<49 (2), 54+0	?54
18	8480	Hardly =54	?55
20	8482	,,	?55
24	8486	,,	?55
27	8489	<54, just vis. naked eye	
Oct. 15	8507	64+5, 75−7	68
Nov. 8	8531	75−4	71
1855			
Apr. 21	8695	Invis.	
May 3	8707	,,	
June 23	8758	,, <92	
Aug. 1	8797	Abt. 92+0	?92
2	8798	?92+0	?92
24	8820	$\frac{75+81}{2}$	78
30	8826	$64+\frac{2}{3}(75-64)$	71

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1855	239+		
Sept. 5	8832	64+3	67
6	8833	64−2	62
13	8840	51+9, 64−4	60
18	8845	Abt. =54 (barely vis.)	?54
21	8848	51+0	51
24	8851	49+2, 51−2	50
26	8853	?49+0 (hazy and ☽)	?49
29	8856	Between 49 and 51	50
30	8857	49 (1)−2, 51−3, 48+1	48
Oct. 2	8859	49 (1)+0 (not v. clear)	49
3	8860	48+1, 49−2	48
7	8864	49−2, 48−2	46
,,	,,	48+1, 49−2	48
11	8868	48+2, 51−3, 49+2	50
12	8869	48−1, 49−2, 51−3	47
14	8871	48+1, 49−2	48
,,	,,	49+1, 51−3	49
15	8872	49+2, 51−2	50
16	8873	Between 49 and 51	50
17	8874	51+0	51
18	8875	49+2, 51−1	50
19	8876	49+2, 51−2	50
21	8878	49+2, 51−2, 48+2	50
,,	,,	48+2, 51−2, 49+1	50
23	8880	Invis. naked eye; ☽ 51−2	49
,,	,,	51−2, 48+2, 49−1	49

1855 Oct. 11, "decreasing." Oct. 12, "brightened." Oct. 16, hazy.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1855	239+		
Oct. 24	8881	48+2, 51−2, 49−1	49
27	8884	49+3, 51+2	52
31	8888	51+3, 54−2	53
,,	,,	$\frac{51+64}{2}$* or fainter	?58 (or 52)
Nov. 1	8889	51+3, 54−2	53
2	8890	54−2	52
3	8891	51+3, 54−2	53
4	8892	51+⅔(64−52), 51+5	58
8	8896	51+9, 64−2	61
9	8897	51+7, 64−3	60
15	8903	64−2	62
20	8908	64+2, 75−11	65
25	8913	64+5, 75−7	68
Dec. 5	8923	64+10, 75−5	72
18	8936	Between 75 and 81	
1856			
May 4	9074	Invis. <92	
10	9080	,, ,,	
19	9089	,,	
26	9096	,,	
July 8	9139	,,	
30	9161	,,	
Aug. 6	9168	,, ,,	
19	9181	,,	
22	9184	92+6, 96+0	97
28	9190	Abt. 92+0	?92
29	9191	92+4, 90+4	95
31	9193	92+4, 90−2	92
Sept. 2	9195	90−3, 92−4	88
4	9197	90−3, 92−4	88
,,	,,	90−2, 92−3	88
1856 Oct. 24, hazy.			

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1856	239+		
Sept. 5	9198	90−2, 92−4	88
6	9199	90−2, 92−4	88
7	9200	90−3, 92−5	87
17	9210	81+4, 92−8	84
19	9212	81+3, 88−6	83
21	9214	81−2	79
22	9215	81−2	79
24	9217	81+2	83
29	9222	75+⅔(81−75)	79
,,	,,	75+¾(81−75)	80
Oct. 1	9224	75+⅓(81−75)	77
5	9228	75−4	71
17	9240	64−1	63
19	9242	64−3	61
,,	,,	61−1	60
24	9247	64−4	60
27	9250	Vis. naked eye, between 49 (2) and 54, perhaps nearer to 49	?51
29	9252	51+¼(64−52)	54
31	9254	51+$\frac{2}{3}$(64+52), 51+3	54
Nov. 6	9260	47−2	45
8	9262	41+4, 47−2	45
9	9263	41+4, 47−2	45
10	9264	41+5, 47−2	46
11	9265	41+5, 47−2	46
12	9266	41+5, 47−1	46
,,	,,	47−1	46
13	9267	47+2, 41+8	49
14	9268	47−1	46
,,	,,	47−1, 41+8	48
15	9269	47+2	49
24	9278	47+2, 49−2	48
27	9281	49+1, 47+2	50
Oct. 29, hazy.			

* ? error for 54.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1856	239+		
Nov. 27	9281	47+2, 49−2, 51−4	48
29	9283	49+⅔(51−49)	50
30	9284	49−1	48
Dec. 1	9285	49+2, 51−3	50
3	9287	49+2	51
,,	,,	51−1	50
,,	,,	51+2, 49+4	53
9	9293	51+4	55
14	9298	$\frac{51+64}{2}$	58
18	9302	51+½(64−52), 59+0	58
26	9310	64−2	62
,,	,,	61−2, 59+2	60
28	9312	61−2, 59+2	60
1857			
Jan. 13	9328	75−1½(81−75), 75−2	66 or 73
19	9334	Invis. (haze)	
24	9339	75+⅓(81−75)	77
Feb. 3	9349	75+⅔(81−75)	79
11	9357	81+8, 90−4, 88−4	86
June 17	9483	Invis.	
24	9490	,, <12·5	
July 12	9508	,,	
16	9512	,,	
19	9515	,,	
Aug. 20	9547	,,	
22	9549	115+0, 124−5, 125−3	119
Sept. 7	9565	112+2, 114−1, 111+2	113
10	9568	Abt. 112+5, abt. min. vis. −4	? 117
12	9570	110−0, 111−2, 114−3	110
19	9577	110−5, *92+2	? 100 (or 103)
20	9578	99+2	101
22	9580	99+3, 110−3	104
28	9586	99+3, 110−4	104
Oct. 4	9592	99+2, 110−6	102
8	9596	99+1, 110−6	102
28	9616	Abt. 100+0	? 100
Nov. 11	9630	92+2	94
15	9634	92−2, 88+0	89
18	9637	75+0, 81−2	77
25	9644	75−2, 64+8	72
Dec. 4	9653	? 61+1, 64−2	62
7	9656	64−2, 52+⅔(64−52)	62
19	9668	49+0	49
20	9669	49−1	48
25	9674	41+3, 49−3	45
1858			
Jan. 1	9681	Perhaps 41+2	? 43
4	9684	41+0, 49−4	43
5	9685	41+0	41
9	9689	41+2	43
11	9691	41+2, 49−3	44
13	9693	41+2, 49−3	44
16	9696	Abt. 41+5 and 49+0	? 48
20	9700	49−1	48
30	9710	52−1	51
Mar. 6	9745	64+4, 75−3	70
Apr. 1	9771	81+10, 92−7	? 88
4	9774	81+10 ?, 92−4, 88−3	88

1856 Dec. 9, ☽ and clouds. Dec. 14, low. 1857 Dec. 25, hazy.
1858 Jan. 1, hazy. Apr. 1, poor observation.

* ? error for 99.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1858	239+		
Apr. 9	9779	81+1, 88−4, 92−4	85
23	9793	88+2, 92−1	90
May 3	9803	92+3	95
4	9804	92+1	93
10	9810	92+4, 99−1	97
11	9811	92+4, 99−1	97
June 4	9835	Much<110 or 112	
13	9844	Invis.<110+10	
21	9852	? glimpsed	
July 6	9867	Suspected	
18	9879	Glimpsed steadily	
30	9891	Invis., sky clear	
Sept. 21	9944	Suspected	
Nov. 5	9989	Invis.	
6	9990	Just vis. 13·5	
11	9995	Min. vis. −3	
	240+		
22	0006	Invis. ☽ and haze	
Dec. 2	0016	119+0	119
29	0043	112+1, 115−3	112
1859			
Jan. 23	0068	92+0, 81+10	92
Feb. 28	0104	75−2	73
Sept. 28	0316	Not seen	
Nov. 30	0379	119−2	117
Dec. 21	0400	99+3, 100−3	100
1860			
Apr. 5	0506	51+2, 64−6	56
11	0512	51+3, 64−10	54
23	0524	64−3	61
1861			
Apr. 8	0874	99+1	100
17	0883	81+0, 92−7	83
29	0895	75−1	74
May 9	0905	75−3	72
17	0913	?64+7, 75−3	?72
27	0923	?64+7, 75−2	?72
29	0925	?64+7, 75−2	?72
30	0926	?64−8, 75−2	?72
June 14	0941	75−1	74
17	0944	75+2, 81−1	78
Aug. 5	0993	92+4, 100−2	97
Sept. 20	1039	12 mag. (clouds)	
Oct. 28	1077	Glimpsed. ? right *	
1862			
Apr. 29	1260	75−1	74
May 16	1277	?64+2, 75−8	?66
19	1280	?64+1, 75−10	?65
June 16	1308	51−3	48
17	1309	51−3	48
28	1320	49+1, 51−3	49
July 4	1326	51−3	48
,,	,,	49+1, 51−3	49
12	1334	49+1, 51−2	50
14	1336	51+0	51
19	1341	51+2	53
,,	,,	51+1½	52
24	1346	51+5	56
,,	,,	51+5, ?64−5	?58
Sept. 20	1404	75+0, 81−4	76
Oct. 29	1443	99−2, 100+1	99
Nov. 24	1469	?110+0	?110
1863			
Feb. 14	1551	Invis.<11·2 low	
May 8	1634	,, <10·5	
17	1643	112+4, 113+2, 114−3	114
June 12	1669	100+0, 110 or 112−3	105
22	1679	99+0	99
30	1687	92+4, 99−3	96

1862 June 28, hazy. July 14. ☽ and clouds.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1863	240+		
July 8	1695	?88−1	?87
17	1704	75−1	74
26	1713	61+0, 64−2	62
Aug. 4	1722	51+4, 64−8	56
5	1723	51+4 (naked eye)	55
15	1733	51−2	49
24	1742	49+0, 51−3	48
Sept. 4	1753	49+0	49
5	1754	49−1	48
9	1758	49+3, 51+0	52
19	1768	51+5 (6·0)	56
28	1777	51+10, 64−5	60
29	1778	51+12, 64−3	62
Oct. 13	1792	61+2, 68−3	64
24	1803	61+4, 71−7, 68+0	67
30	1809	61+6, 75−4	69
Nov. 2	1812	61+4, 75−4	68
11	1821	61+7, 75−1	71
19	1829	75+2, 81−4	77
Dec. 5	1845	81+0, 92−7	83
17	1857	81+5, 92−2	88
1864			
Apr. 25	1987	Not seen <11·0	
May 13	2005	,, <12·5	
July 14	2067	88+2, 98−5	88
19	2072	81+2, 92−7	84
29	2082	75+5, 81−2	80
Aug. 21	2105	81−3	78
23	2107	81−3	78
31	2115	64+2, 75−9	66
Sept. 9	2124	61+0, 64−3	61
14	2129	61−3, 64−5	58
24	2139	51+0, 64−9, 61−9	53
27	2142	51−1	50
Oct. 3	2148	51−2	49
7	2152	51−4, 49−1	48
8	2153	51−4, 49+0	48
9	2154	51−4, 49+0	48
13	2158	51−3	48
16	2161	51−3	48
24	2169	51−2	49
31	2176	51−1 (abt.)	?50
Nov. 5	2181	51+1	52
8	2184	51+0	51
23	2199	64−3	61
1865			
Apr. 15	2342	Not seen <12·5	
June 9	2397	,, <11·5	
Nov. 1	2542	51+2, 61−10	52
5	2546	51+0	51
12	2553	51−2	49
15	2556	51−3	48
26	2567	51−2 (invis. n. eye, ☽)	49
Dec. 22	2593	51+3, 61−5	55
1866			
May 20	2742	13·0	
June 25	2778	Not seen <12·5	
Sept. 8	2853	,, <12·0	
17	2862	12·2	
Oct. 6	2881	105−1	104
9	2884	100+2, 105−3	102
16	2891	100+1, 105−5	100
Nov. 3	2909	92−4	88
9	2915	75+3, 81−0	80
19	2925	75+2, 81−2	78
25	2931	61+7, 75+0, 81−3	74
30	2936	61+5, 75−1	70
Dec. 8	2944	61+3, 75−3	68
16	2952	61+0	61
30	2966	75+2	77

1864 Oct. 24, hazy.

1866 Dec. 8, very hazy.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1867	240+		
Jan. 11	2978	75−3	72
Feb. 1	2999	75−2	73
Dec. 12	3313	99−2	97
1868			
Jan. 26	3358	81−1	82
Apr. 11	3434	51−1 (finder, 51+2)	? 50
23	3446	64−3	61
1869			
Apr. 30	3818	51+0	51
June 8	3857	64+2, 61+3	65
1870			
June 5	4219	51−1	50
1874			
Nov. 11	5839	51−1	50
Dec. 13	5871	51+5	56
1875			
Dec. 5	6228	51−3	48
20	6243	51−4	47
1878			
May 11	7116	75+0	75
21	7126	75−1	74
June 1	7137	81+2	83
Nov. 28	7317	About 13·2	
1879			
Jan. 13	7363	100−1	99
15	7365	100−1	99
19	7369	92+0, 100−5	94
22	7372	92−2	90
Sept. 23	7616	Invis.	
Nov. 5	7659	,,	
1880			
Mar. 17	7792	92+0	92
1880	240+		
Apr. 11	7817	81+5, 92−7	86
17	7823	75+1, 81−2	78
24	7830	61+1	62
29	7835	61−3, 64−2, 51+4	58
May 5	7841	51+3, 61−3	56
13	7849	51+0	51
June 4	7871	51+0	51
17	7884	51−1	50
July 4	7901	51+1	52
Aug. 9	7937	81−2	79
1881			
May 29	8230	75−2	73
June 12	8244	61+2, 64+0	64
18	8250	61−2	59
July 11	8273	51+0, 61−10	51
20	8282	61−8, 51+0	52
Aug. 1	8294	51+1, 61−10	52
24	8317	51+5, 61−2	58
Sept. 14	8338	61+7, 75−7	68
1882			
May 14	8580	Glimpsed 13·7	
July 9	8636	75+0, 81−4	76
26	8653	61+0, 64−1	62
Sept. 9	8698	61−10, 51−3	50
1884			
July 12	9370	About 13·0	
Aug. 11	9400	105+1, 108+2	108
Sept. 2	9422	92+10, 100−3	100
11	9431	92+2	94
19	9439	92+4, 100−7	94
20	9440	92+8, 100−4	98
Oct. 1	9451	92−1	91
5	9455	92−5	87
12	9462	92−8, 75+3, 81−3	80

1867 Feb. 1, strong twilight.

TABLE XIII.—*Observations of χ Cygni*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1884	240+		
Nov. 7	9488	51−5, 61−8	50
9	9490	51−1, 61−8	52
13	9494	51−3	48
20	9501	51−5	46
27	9508	51−5	46
Dec. 3	9514	51−6	45
14	9525	51+1	52
21	9532	51−1	50
24	9535	51+3	54
1885			
Jan. 11	9553	51+3, 64−5, 61−4	57
May 11	9673	Invis.<13·5	
Aug. 14	9768	Glimpsed<13·6	
Nov. 15	9861	81+12, 92−5	90
19	9865	81−2	79
28	9874	75−1	74
Dec. 1	9877	75−5	70
26	9902	51−4	47
1886	240+		
Jan. 4	9911	51−4	47
6	9913	51−7	44
11	9918	51−7	44
15	9922	51−8	43
26	9933	51−5	46
Feb. 4	9942	51−5	46
	241+		
Sept. 18	0168	Invis.<13·6	
Oct. 25	0205	114−3	111
Nov. 2	0213	108+4, 114−5	110
17	0228	105+5, 108−3	108
Dec. 4	0245	105−2, 108−5	103
20	0261	105−2, 108−6	102
29	0270	100−1	99
1887			
Jan. 12	0284	81+6, 92−5	87

1886 Jan. 6, clear.

A period of about 409 days seemed to be suggested by the observations (this can almost be deduced from the dates of naked-eye observations given above, before Table XIII., alone); so they were arranged and tabulated in the usual manner with an assumed period of that length. But Baxendell could not see this star anywhere near its minimum, so that one of the 12 "portions" is vacant throughout the whole time (except for entries of "not vis."), and 3 other portions have only from one to three actual observations, generally vague or doubtful. The means of two groups of periods are given below: A consists of periods II. to XVI. (2393759 to 9893), and B of XX., XXII., XXIII., and XXVII. to XLI. (2401121 to 2410118, with gaps). Periods XVII., XIX., XXI., XXIV., XXV., and XLII. are omitted, because the variable appeared to be abnormally faint at those times, and Period XXVI. because the maximum seems to come much later than usual, unless the star is abnormally bright at that epoch,—there are only two observations. The magnitude at maximum seems to range from 4·4 to 7·3, but is usually a little above or below 5·0; that at minimum is not shown.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	...	(119)	108	93	74	51	51	69	83	95	...	(<112)
B	...	(?132)	122	93	77	52	49	59	78	99	(110)	(130)
Weighted Mean	...	124	111	93	75	52	50	65	82	96	(111)	—
No. of Observations	...	2	10	27	45	78	90	28	21	9	1	2

The figures in brackets are those of single observations which are not central in the portion.

The means for portions 2 to 10 give quite a good curve, as far as it goes, and the individual observations have been compared with it for each period in which there are any available both before and after maximum, to find "corrections to epoch." The place of maximum in the curve appears to be about 205 days after the arbitrary initial date of the period. Table XIV. gives the results. The details for the separate portions are not given, to save printing. *General* differences in magnitude have been allowed for.

TABLE XIV.

Baxendell's Maxima of χ Cygni.

Period.	Adopted Date. 2390000+	Calculated Corr.	No. Obs.	Period.	Adopted Date. 2400000+	Calculated Corr.	No. Obs.
I.	3555	...	0	XXII.	2144	+ 8	21
II.	3964	...	4	XXIII.	2553	+ 4	7
IV.	4782	...	1	XXIV.	2962	− 4	13
V.	5191	...	15	XXV.	3371	+37	4
IX.	6827	...	15	XXVI.	3780	...	2
X.	7236	...	6	XXVII.	4189	...	1
XI.	7645	...	6	XXXI.	5825	...	2
XII.	8054	0	15	XXXII.	6234	...	2
XIII.	8463	− 6	13	XXXIV.	7052	...	2
XIV.	8872	− 2	44	XXXV.	7461	...	5
XV.	9281	− 9	57	XXXVI.	7870	− 3	11
XVI.	9690	− 1	36	XXXVII.	8279	0	8
XVII.	0099	+ 8	6	XXXVIII.	8688	− 1	3
XVIII.	0508	+ 2	5	XL.	9506	+ 9	18
XIX.	0917	+ 4	12	XLI.	9915	+ 8	11
XX.	1326	− 5	17	XLII.	0324	...	7
XXI.	1735	+18	25				

Considering the length of the period, and the comparative fewness of the observations, any correction of less than 10 days may

be considered negligible, and there are only two which exceed this amount—those for Periods XXI. and XXV., both of which are supported by the appearance of the observations, though in the case of XXV. (the largest correction) there are only four observations available. In Period V., too, the epoch would seem to be *about* ten days later than the mean date, but the observations are not definite enough for any certain result. In Period XV. the observations suggest an epoch of maximum about 18 days before the mean date, instead of 9 days as given by calculation. With these three or four exceptions, the place of maximum might lie throughout the whole series within a few days of the mean position for a regular period of 409 days.

As practically 4 of the 12 "portions" are unobserved, it is not possible to analyse the curve without relying too much on conjecture for the absent part.

No. 28, *U Herculis* (5889 *Chandler*).

$16^h\ 19^m\ 24^s{\cdot}1$	$+19^\circ\ 12'{\cdot}7$	(1855·0)
16 21 22	+19 7·2	(1900·0)

Identification of Comparison Stars.—There are five charts, in which the designations differ a good deal, but it is not difficult to identify them one with another, and Baxendell himself wrote a list of identifications for the two principal charts.

TABLE XV.

Baxendell's Comparison Stars.

Sketches. 1863 May 25.	1863 June 20.	1864 Sept. 24.	1865 Aug. 25.	1866 Apr. 21.	A.S.V. No.	A.S.V. Grade.	H.A. 37, p. 170.	Adopted Mag.
a	...	*a'*	...	...	...	...	...	...
b	...	*a*	...	...	1	...	...	72
c	...	*b*	...	...	...	...	7·81	·78
d	...	*c*	...	...	2	0	...	83
e	...	*d*	...	...	4	7	8·96	90
e	...	...	...	...	...	...	8·61	86
h and *e*	A	*e*	*e*	...	5	12	9·29	93
...	...	*f*	...	...	8	23	...	99
...	...	*g*	...	...	10	33	10·36	104
f'	...	...	...	...	...	...	...	...
g'	...	...	...	...	...	...	...	...
*	*a*	*h*	*h*	...	11	40	10·88	109
...	*b*	*k*	...	...	13	49	...	112
...	*c*	*l*	...	*l*	15	56	11·60	116

* This letter is illegible.

TABLE XVI.

Baxendell's Differences between his Comparison Stars.

Years.	78–72.	83–78.	90–83.	93–90.	109–93.	112–109.	116–112.	83–72.	93–83.	116–109.	86–72.
1863–5	$5^{\cdot}0_1$	$4^{\cdot}0_1$	$10^{\cdot}0_1$	...	$19^{\cdot}8_2$	...	$4^{\cdot}0_4$	$12^{\cdot}0_1$	$14^{\cdot}0_1$	$10^{\cdot}5_2$	$11^{\cdot}3_5$
1866–8	$7^{\cdot}4_4$	$6^{\cdot}7_3$	$14^{\cdot}0_1$	$3^{\cdot}0_2$	...	$4^{\cdot}0_1$	$10^{\cdot}0_3$	...	$13^{\cdot}0_2$	...	...
1878–80	$6^{\cdot}7_3$	$4^{\cdot}7_2$	...	...	$16^{\cdot}0_1$	$5^{\cdot}3_6$	$7^{\cdot}1_4$	$11^{\cdot}2_2$	...	$10^{\cdot}3_2$	...
1881–5	$6^{\cdot}5_4$	$5^{\cdot}7_6$	$5^{\cdot}3_3$	$4^{\cdot}2_4$	$15^{\cdot}0_1$	$9^{\cdot}2_2$	$4^{\cdot}3_8$	$11^{\cdot}5_{10}$	$8^{\cdot}8_3$	$12^{\cdot}5_1$	...
Mean	6·7	5·6	8·0	3·8	17·6	6·0	6·2	11·5	11·1	10·8	11·3
No. of Obs.	12	12	5	6	4	9	14	13	6	5	5
Reduced Mean	5·8	4·9	6·7	3·2	13·3	5·3	5·4	9·9	9·4	9·3	9·7

The five observed intervals between the stars *c* and *d* (83 and 90) are 2, 6, 8, 14, and 10. Only one of them is a direct comparison, however; in the other cases each of these stars is compared with the variable. Most of the other intervals also vary greatly, and the comparisons are in all cases so few that little weight can be attached to the means.

The telescopes used were A 68 in the first series, and E 80 in the second. But C 39 was used 1863 May 25 and 26, and 1864 May 15; and p. 125 was used 1878 Sept. 13.

TABLE XVII.

Baxendell's Observations of U Herculis.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1863	240+		
May 25	1651	93+10	103
26	1652	93+12	105
June 20	1677	109+1, 112−2, 93+14	109
23	1680	109+2, 112+0, 93+17	111
25	1682	109+2	111
July 3	1690	109+3, 112−1, 116−3	112
Aug. 24	1742	116+6, "glimpsed steadily"	122
Sept. 5	1754	116+10, "glimpsed steadily"	126
Oct. 9	1788	"Invisible; very low"	
Nov. 2	1812	116+7, min. vis. −3	123
10	1820	116+2	118
29	1839	>116	
1864			
May 15	2007	86−1	85
16	2008	86−2	84
24	2016	86+0	86
26	2018	86+0	86
29	2021	86+1	87

1863 Nov. 10, "very low, but good observation." Nov. 29, "*l* and U barely glimpsed; very low, and just on the trees. Def. bad."

1864 May 16, "U vanishes before *e*."

TABLE XVII.—*Baxendell's Observations of U Herculis*—continued.

Date.	J.D. 240+	Corrected Comparisons.	Deduced Mag.
1864			
June 6	2029	86+4	90
July 4	2057	109+0	109
13	2066	109−1	108
26	2079	109+1	110
Aug. 21	2105	116−3	113
26	2110	109+10, 116−2	116
Sept. 24	2139	116+3	119
26	2141	116+4	120
Oct. 3	2148	116+6	122
1865			
Apr. 2	2329	72+6, 86−3, 78−2	79
8	2335	72+1	73
10	2337	72+0	72
15	2342	72+0	72
24	2351	72+0	72
26	2353	72−1	71
May 1	2358	72−1	71
6	2363	72−1	71
15	2372	72+0	72
18	2375	72+1	73
20	2377	72+1	73
24	2381	72+1	73
June 9	2397	72+3, 86−6	78
13	2401	72+3, 86−4	78
17	2405	72+7, 86−3	81
20	2408	72+8, 86−3	82
July 1	2419	86−3	83
13	2431	86+2, 90+0	89
21	2439	90+2, 93−2	92
Aug. 25	2474	109−3	106
Sept. 7	2487	109+0	109
28	2508	112+1	113
Oct. 7	2517	112+1, 116−2	114
1866			
Apr. 21	2713	Not seen, < 116+6	
22	2714	116+1	117
23	2715	116+1	117
24	2716	116−1	115
May 7	2729	93+5, 104−5	98
15	2737	93−1	92
17	2739	93−1	92
20	2742	93−3	90
22	2744	93−3	90
26	2748	93−4	89
June 8	2761	93−5	88
25	2778	90−2, 93−5	88
July 11	2794	93−2	91
16	2799	93−1	92
19	2802	93−2	91
21	2804	93+2	95
30	2813	93+5	98
Aug. 20	2834	109−3	106
31	2845	109+1	110
Sept. 17	2862	109+3, 112+0, 116−10	110
Oct. 6	2881	112+6, 116−2	116
10	2885	112+6, 116−2	116
Nov. 6	2912	116+7	123
1867			
Feb. 1	2999	< 112+4 (not seen)	
Apr. 11	3068	116+8 (glimpsed)	124
21	3078	116+7	123
May 14	3101	116+6	122
21	3108	116−1	115
June 5	3123	109+0	109
29	3147	83−2	81
July 24	3172	72+4, 78−3	76
27	3175	72+3, 78−3	75
Aug. 1	3180	72+4, 78−2	76
6	3185	72+6, 78−1	78
21	3200	78+6, 78−1	84
Sept. 2	3212	83+4	87
10	3220	83+7	90

1866 Aug. 20, ☽, hazy. Nov. 6, "occasionally glimpsed."

TABLE XVII.—*Baxendell's Observations of U Herculis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1867	240+		
Sept. 16	3226	83+10, 90−2, 93−3	90
Oct. 3	3243	93+3	96
1868			
Apr. 9	3432	Not vis., <116+4	
11	3434	,, ,, <13·2	
23	3446	,, ,, <13·0	
May 11	3464	116+6, min. vis. −4	122
20	3473	116+3	119
30	3483	116+3	119
June 4	3488	116+3	119
7	3491	116+2	118
16	3500	116+3	119
19	3503	116+1	117
29	3513	116−2	114
July 10	3524	116−1	115
23	3537	109+0	109
25	3539	109−2	107
Sept. 6	3582	78+2, 83−3	80
11	3587	78−3, 83−3	80
Oct. 17	3623	83+3, 93−6	86
Nov. 6	3643	93+1	94
8	3645	93+2	95
1869			
Apr. 12	3800	116+8	124
30	3818	116+7	123
June 8	3857	Not seen, <116+6	
1878			
June 10	7146	116+4	120
23	7159	116+6	122
28	7164	116+4	120
July 19	7185	116−1	115
28	7194	116−2	114
31	7197	116−3	113
Aug. 8	7205	112+3, 116−7	112
18	7215	109+4, 116−6	112
25	7222	109+6, 112−1	113
28	7225	109+6, 112+0	114
Sept. 9	7237	109+3, 112−3	110
11	7239	109−2, 212−7	106
13	7241	109−3	106
24	7252	99+2, 104−6,* 109−7, ?112−9	?101
Oct. 17	7275	72+8, 90−6, 78+3	82
26	7284	72+6, 83−4, 78+0	78
Nov. 1	7290	72+3, 78−3, 83−6	76
1879			
Mar. 1	7410	93+6, 99−2	98
5	7414	93+7, 109−7	101
31	7440	109+0	109
Apr. 6	7446	104+2, 109−2	106
Aug. 11	7573	116+0	116
14	7576	116−1	115
23	7585	112+4, 116−2	115
Sept. 13	7606	116−4, 112−2	111
25	7618	112−1	111
Oct. 6	7629	109−1, 112−3	108
15	7638	109+0	109
Nov. 2	7565	93+0	93
1880			
May 1	7837	104−2	102
16	7852	104+0, 109+0	106
28	7864	109+3, 116−4	112
July 20	7917	116+2	118
31	7928	116+2	118
Aug. 9	7937	116+5	121

1868 Apr. 9, ☽ ☽, but sky very clear.
1878 Aug. 8, clouds.
1869 June 8, hazy sky.
1879 Oct. 6, "dry, hazy sky."

* The letter is *l*, but it seems probable *g* is meant.

TABLE XVII.—*Baxendell's Observations of U Herculis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1880	240+		
Aug. 13	7941	116+6	122
28	7956	116+1	117
Sept. 5	7964	116+1	117
8	7967	116+1	117
28	7987	116−2	114
Oct. 9	7998	112+3, 116−4	114
21	8010	116−2	114
29	8018	116−1	115
1881			
Apr. 1	8172	93−2	91
20	8191	93−2	91
May 7	8208	93+4	97
10	8211	93+6	99
July 14	8276	116−1	115
27	8289	116−1	115
Aug. 1	8294	116+1	117
24	8317	116+10, 132−12	?123
Sept. 1	8325	About 13·0	
19	8343	132−4; abt. 128	?128
Oct. 2	8356	<116+8	<124
16	8370	116+3, 132−10	120
29	8383	116+3	119
Nov. 20	8405	116−2	114
1882			
Apr. 20	8556	83+3, 90−4	86
May 12	8578	90−1, 93−5	88
14	8580	90+0, 93−3	90
19	8585	93+0	93
July 26	8653	116−4, 112−2	111
Aug. 19	8677	112+3, 116−2	114
Sept. 9	8698	116+1	117
1883			
Mar. 12	8882	Between 83 and 93	
24	8894	72+3, 83−6	76
Apr. 8	8909	72+1, 83−7	74
1884			
Mar. 21	9257	116+0	116

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1884	240+		
Apr. 7	9274	109+6, 116−5	113
28	9295	83+3, 93−5, 90−2	87
May 4	9301	72+9, 83−3	80
18	9315	83−3	80
22	9319	78+0, 83−5	78
24	9321	72+3, 83−5, 78−1	77
30	9327	72+5, 83−6, 78−1	77
June 4	9332	72+4, 83−6, 78−1	77
11	9339	72+4, 83−5	77
20	9348	72+8, 83−4, 78+2	80
25	9353	78+2, 83−3	80
July 2	9360	83+3	86
25	9383	83+4, 93−3	88
27	9385	83+6, 93−1	90
Aug. 11	9400	93+6, 99−4	97
14	9403	93+8, 109−4	103
23	9412	116−2	?104−2* [114] ?102
Sept. 5	9425	104−5	99
13	9433	109−3	106
20	9440	109+3	112
Oct. 1	9451	109−2	107
Nov. 19	9500	116+4	120
1885			
Apr. 2	9634	116+1	117
8	9640	116+3	119
17	9649	116+3	119
23	9655	116−1	115
May 7	9669	112−2, 116−6	110
10	9672	112−3	109
16	9678	109+1, 112−7	108
20	9682	109+0, 112−7	107
June 1	9694	93−3	99

1880 Oct. 21, "Def. very bad."

1881 Oct. 2, "low and only glimpsed."

TABLE XVII.—*Baxendell's Observations of U Herculis*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1885	240+		
June 9	9702	83−1, 90−3	84
July 4	9727	83−3	80
9	9732	72+3, 83−7	76
26	9749	72+6, 83−3	79
Aug. 14	9768	83+0	83
20	9774	83−1	82
28	9782	83+2	85
1886	241+		
Apr. 9	0006	116+7	123
26	0023	116+0	116
May 21	0048	116−1	115
Sept. 17	0167	83−3	80
Nov. 2	0213	93−1	92

These observations have been tabulated and dealt with in the usual manner, with an assumed period of 409¾ days, which seemed on the whole to fit them best. The result, for the whole of the observations divided into three groups of periods, is shown below:—

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	111	113½	122	126	126	121½	117	95	79	85	92½	102
B	99½	107½	...	118	119½	117	113	106½	87	76	...	91
C	104	116½	116½	126½	123½	117	114½	98½	77	81	89	98
Weighted Mean with B shifted.	109	115	120	124	123	118	114	95	78	83	91	101
Curve as drawn.	109	115	120	124	123	119	113	95	78	83	91	101

The unit is 0·1 magnitude. A consists of periods I. to VI.; B, XIV. to XVI.; C, XVII. to XXI. The star was not observed between A and B. It is clear that in B the maximum and minimum are advanced by something like one portion, but when the portions are shifted accordingly, we find that the star is brighter throughout half the curve. The weighting is by the number of periods included in the portions, but with half weight for B as being both less complete and also somewhat doubtful as regards position.

The curve is fairly smooth, and the maximum appears to be about 297 days, and the minimum 133 days, after the arbitrary starting point. The individual observations have been compared with the curve in the usual manner, to obtain "corrections to epoch." These corrections were obtained separately for minimum and maximum, the observations being arranged so as to have the place of maximum or minimum (respectively) as nearly central as possible.* The resulting "observed" epochs are compared, in the following table, with a uniform period of 409·75 days. With the exception of periods XIV. to XVII., the uniform period fits quite

* Nevertheless, the position is often by no means central; but no periods have been taken unless there were *some* observations available on both sides of the epoch in question. *General* variations of brightness were taken into account.

well; but the exception is striking and unmistakable. A discontinuity solution—consisting of a period of 410 days from I. to VI., 413 from VI. to XIV. (not observed), 403 from XIV. to XVIII., and 408 from XVIII. to XXI.—would fit all the observed epochs.

In *H.A.* (**55**, 194) a large number of epochs of this star are collected, from various observers, and it is interesting to see to what extent they agree with the uniform period and with a slightly modified discontinuity solution, as shown in Table XIX., for maxima only.

TABLE XVIII.

Epochs of Minima and Maxima.

	Minima.				Maxima.		
E.	Period.	Uniform.	Observed.	O−U.	Uniform.	Observed.	O−U.
−13	I.	1783	1787	+ 4_4	1947	1951	+ 4_6
−12	II.	2193	2192	− 1_6	2357	2357	0_7
−11	III.	2603	2602	− 1_6	2767	2765	− 2_6
−10	IV.	3012	3010	− 2_7	3176	3176	0_6
− 9	V.	3422	3424	+ 2_5	3586	3589	+ 3_7
0	XIV.	7110	...	...	7274	7299	+ 25_8
+ 1	XV.	7520	7537	+ 17_6	7684	7702	+ 18_4
+ 2	XVI.	7929	7943	+ 14_4	8093	8104	+ 11_6
+ 3	XVII.	8339	8348	+ 9_5	8503	8511	+ 8_6
+ 4	XVIII.	8749	...	...	8913	...	...
+ 5	XIX.	9159	...	...	9323	9328	+ 5_8
+ 6	XX.	9568	9567	− 1_8	9732	9736	+ 4_6
+ 7	XXI.	9978	9980	+ 2_4	0142	0143	+ 1_4

The subscript figures give the number of "portions" included in the calculation.

TABLE XIX.

Maxima of U Herculis, from H.A.

Epoch.	Observed.	Uniform.	O−U	Disc. 410d.	O−D.	Epoch.	Observed.	Uniform.	O−U	Disc. 416d.	O−D.
−16	0711	0718	− 7	0715	− 4	−3	6055	6045	+10	6051	+ 4
−15	1109	1128	−19	1125	−16	0	7299	7274	+25	7299	0
−14	1538	1537	+ 1	1535	+ 3					404d.	
−13	[1951	1947	+ 4	1945	+ 6]	+1	7703	7684	+19	7703	0
−12	2359	2357	+ 2	2355	+ 4	2	8096	8093	+ 3	8107	−11
−11	2764	2767	− 3	2765	− 1	,,	[8104	,,	+11	,,	− 3]
−10	3167	3176	− 9	3175	− 8]	3	8512	8503	+ 9	8511	+ 1
,,	[3176	,,	0	,,	+ 1]	4	8912	8913	− 1	8915	− 3
− 9	[3589	3586	+ 3	3585	+ 4]					410d.	
− 8	3993	3996	− 3	3995	− 2	5	9328	9323	+ 5	9325	+ 3
− 4	5637	5635	+ 2	5635	+ 2	6	9734	9732	+ 2	9735	− 1
						7	[0143	0142	+ 1	0145	− 2

The figures in square brackets are not in *H.A.*, but are Baxendell's dates (given in the previous table), added to make the list more complete, or for comparison. A number of later epochs are given in *H.A.*, and these would indicate for the most part a shortened period, not much exceeding 400 days; but they are somewhat irregular, and the dates given by different observers sometimes differ considerably.

Analysis of the mean light curve gives the expression, in units of 0·1 magnitude,

$$20{\cdot}69\cos(\theta - 89^\circ) + 5{\cdot}48\cos(2\theta - 317^\circ) + 2{\cdot}39\cos(3\theta - 192^\circ)$$

which, when divided by the range, multiplied by 6, and brought to the maximum of the principal term, becomes

$$2{\cdot}64\cos(\theta - 180^\circ) + 0{\cdot}70\cos(2\theta - 139^\circ) + 0{\cdot}30\cos(3\theta - 105^\circ).$$

It is thus an excellent example of Phillips' "Group II." (see *Jour. B.A.A.*, **27**, 7, Oct. 1916), the formula for which is $\phi_3 = 1{\cdot}67\ \phi_2 - 126^\circ{\cdot}8$, giving (for the above value of ϕ_2) $\phi_3 = 105^\circ{\cdot}3$. The range of ϕ_2 in his "Group II." is from 67° to 197°, so that 139° comes well within it.

No. 29, *R Scuti* (6733 *Chandler*).

$18^h\ 39^m\ 45^s \quad -5^\circ\ 51'{\cdot}1 \quad (1855{\cdot}0)$
$18\ \ 42\ \ \ 9 \quad -5\ 48'{\cdot}8 \quad (1900{\cdot}0)$

Identification of Comparison Stars.—Baxendell made seven small sketches for this star, and also used Pigott's chart (published August 1796). The identifications present no difficulty, except as to the star *n*.

TABLE XX.

Baxendell's Comparison Stars.

Pigott's Chart.	Baxendell. 1840 Sept. 18.	1868 July 10.	1877 Sept. 12.	1878 Aug. 8.	1880 July 31.	1881 May 20.	1884 Aug. 23.	H.P.	Adopted Mag.
l	...	...	...	...	...	...	...	4·5*	45
k	...	...	...	...	...	...	...	5·1	51
n	...	...	...	...	...	...	...	6·2	?62
P	*b*	*b*	*a*	*a*	*a*	*a*	*a*	6·2	60
γ	*c*	...	...	*b*	...	...	...	6·5	65
τ	*d*	..	...	*c*	...	...	...	6·9	69

* R.H.P.

The two brightest stars were usually called 6 Aquilæ and 9 Aquilæ.

The identification of the star called *n* with Pigott's *n* is very doubtful. It was used only in 1848, on October 28 and 29 and in November; while "Pigott's *P*" was used only in 1878. If the

identification is correct, the effect in the light curve is very peculiar, and the two comparisons on October 28 differ very greatly. It was said (November 14) to be "just visible to naked eye," and on other occasions the variable is said to be so visible when from 5·0 to 5·5 magnitude. It seems just possible 9 Aquilæ was meant. But Pigott estimated *n* as equal to *k* (9 Aquilæ).

TABLE XXI.

Baxendell's Differences between his Comparison Stars.

Years.	51 – 45.	60 – 51.	65 – 60.	69 – 65.	45 – 60.
1848–9	$6{\cdot}0_{12}$	$9{\cdot}1_{28}$	$6{\cdot}0_{1}$	$7{\cdot}0_{1}$	$14{\cdot}2_{15}$
1850	$6{\cdot}3_{3}$	$9{\cdot}4_{19}$	$5{\cdot}0_{1}$	$3{\cdot}5_{1}$	$14{\cdot}2_{5}$
1851–6	...	$8{\cdot}8_{29}$	$4{\cdot}5_{4}$	$5{\cdot}0_{3}$	...
Mean (old notation)	$6{\cdot}0_{15}$	$9{\cdot}1_{76}$	$4{\cdot}8_{6}$	$5{\cdot}1_{5}$	$14{\cdot}2_{20}$
1857	...	$7{\cdot}4_{25}$*	$1{\cdot}5_{3}$*	$2{\cdot}0_{1}$*	...
1858–9	...	$10{\cdot}6_{24}$	...	...	...
1878	...	$7{\cdot}0_{1}$	$7{\cdot}0_{1}$	$4{\cdot}0_{1}$	...
Mean (new notation)	...	$8{\cdot}9_{50}$	$2{\cdot}9_{4}$	$3{\cdot}0_{2}$	...
General mean . .	(6·0)	9·0	4·05	4·5	(14·2)
No. of observations	(15)	126	10	7	20

The earlier observations were made in the notation explained in *M.N.*, **76**, 171; and they have been interpreted by the table there given, except that when the magnitude borders closely on 6·5, a compromise between the columns B and C was used. There is some suggestion of a periodical variation in the interval between the stars 51 and 60; the evidence is insufficient to show which of them varies, but it seems probable that it is 60, as the result of Baxendell's comparisons disagrees with the H.P. value of that star.

The telescope used in almost all these observations was 30 (*a*); but R ($4\frac{1}{2}$) 37 was used 1846 Oct. 7; finder of 6 feet Newton, 1848 Oct. 28 (second observation) to Nov. 14, and 1849 April 30 and July 23; Tully's A35, 1857 July 12 and 16; A68, 1857 Sept. 7, 16, 17 (first observation), and 19, and 1868 July 23; R (13) 81, 1858 May 5, and 1868 July 27; 22 (*a*), 1859 May 22 to July 18, and Aug. 10 to 1859 Sept. 3 (powers varying from 21 to 39); E 80 from 1878 Aug. 2; opera-glasses in 1877; and sometimes naked-eye observations were made when the variable was near its maximum.

* These comparisons were made very shortly after Baxendell changed his notation, and as they give much smaller intervals than those obtained earlier and later, it seems best (as a working compromise) to treat them as being roughly compensated for by the probable excess in the later ones, and therefore not to apply the usual reduction to these last in taking the means.

TABLE XXII.

Baxendell's Observations of R Scuti.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1840	239+		
May 1	3227	About 6·7, much < 51	?
2	3228	51 + 4	55
Aug. 8	3326	Not visible to naked eye	
Sept. 3	3352	51 + 4	55
18	3367	51 + 3	54
,,	,,	A little > 60	)
Oct. 25	3404	51 − 3	48
1841			
Sept. 12	3726	Not visible to naked eye	
Oct. 3	3747	65 + ¼ (69 − 65)	66
1844			
Aug. 4	4783	Just visible to ? naked eye	60
1846			
Oct. 7	5577	< 65, > 69, much < 60	? 67
Nov. 11	5612	Much > 60	?
1848			
Sept. 4	6275	60 + 1, 65 − ⅖ (69 − 65)	62
19	6290	69 + 6	75
Oct. 5	6306	69 + 7	76
7	6308	Glimpsed < 69	?
10	6311	69 − 4	65
14	6315	69 − 4	65
17	6318	60 − 5	55
18	6319	60 − 4	56
20	6321	60 − 5	55
22	6323	60 − 6	54
28	6329	> 60	
,,	,,	? 51 or ? 62 + 5	
29	6330	? 51 or ? 62 + 2	
Nov. 4	6336	? 51 or ? 62 + 2 (Doubtful − ☽)	
9	6341	? 51 or ? 62 + 2 (Doubtful − ☽)	
14	6346	? 51 or ? 62 − 2 (Both just visible to naked eye)	
1849			
Apr. 17	6500	45 + 5, 60 − 5	52
30	6513	45 + 5, 60 − 5	52
May 4	6517	Visible to naked eye, though ☽	
5	6518	45 + 5, 60 − 10, 51 + 1	51
8	6521	45 + 5, 60 − 10, 51 − 1. Low	50
11	6524	45 + 5, 60 − 10, 51 + 2	51
15	6528	60 − 10	50
23	6536	45 + 8, 60 − 6	54
28	6541	45 + 8, 60 − 6	54
June 2	6546	45 + 11, 60 − 6, 51 + 4 *	55
5	6549	45 + 11, 60 − 6 51 + 3	55
9	6553	45 + 11, 60 − 3	56
10	6554	60 − 3	57
12	6556	60 − 2 Low	58
16	6560	60 − 1 ,,	59
,,	,,	60 − 1	59
17	6561	60 − 1	59
23	6567	60 + 1	61
24	6568	60 − 1	59
July 1	6575	60 − 1	59
4	6578	69 − 2	58
8	6582	60 − 2	58

* Doubtful: not in same field.

TABLE XXII.—*Baxendell's Observations of R Scuti*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1849	239+		
July 9	6583	60−2	58
13	6587	51+5, 60−2	57
14	6588	51+5, 60−2	57
15	6589	51+5, 60+2	57
23	6597	60−3	57
Aug. 3	6608	51+3, 60−6	54
6	6611	51+5, 60−6	55
11	6616	51+3, visible to naked eye	54
12	6617	51+1, 60−6	53
16	6621	51+3, 60−6	54
,,	,,	51+4	55
18	6623	*51+1, 60−6	53
,,	,,	51+2	53
23	6628	51+1, 60−10	51
26	6631	51+1	52
27	6632	45+5, 51−2, 60−10	50
Sept. 3	6639	45+5, 51−2, 60−10	50
5	6641	45+5, 51−2, 60−10	50
7	6643	45+5, 51+1, 60−6	52
11	6647	45+8, 51+2, 60−6	53
17	6653	51+3, 60−6	54
18	6654	51+3, 60−6	54
22	6658	51+3, 60−6	54
Oct. 2	6668	51+3, 60−6	54
10	6676	51+4, 60−4	56
11	6677	51+4, 60−4	56
14	6680	51+4, 60−6	54
16	6682	51+3, 60−6	54
20	6686	51+5, 60−6	55
28	6694	51+4, 60−6	54
Nov. 16	6713	51+3, 60−6	54

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1850	239+		
May 26	6904	45+5, 60−6	52
31	6909	45+8, 51+2, 60−6	53
June 1	6910	45+8, 60−6	54
18	6927	51+5, 60−2	57
22	6931	51+5, 60−2	57
July 4	6943	51+4, 60−6	54
8	6947	51+3, 60−6	54
13	6952	51−1, 60−10, vis. to naked eye	50
15	6954	51+1	52
20	6959	51−2	49
28	6967	51+1	52
,,	,,	51−1	50
Aug. 3	6973	51+3, 60−6	54
6	6976	51+2, 60−6	54
14	6984	51+4, 60−6	54
21	6991	51+5, 60−5	56
Sept. 5	7006	51+4, 60−6	54
7	7008	51+2, 60−7	53
9	7010	51+2, 60−10, hazy	52
11	7012	51+2, 60−10	52
15	7016	51+2, 60−10	52
Oct. 11	7042	51+4, 60−5	55
21	7052	60+5, 65+0, 69−3	65
29	7060	69+3	72
Nov. 2	7064	69+3	72
27	7089	51+2, 60−6	54
1851			
June 27	7301	51+2, 60−4	54
July 17	7321	51+3, 65−2	56
21	7325	51+3, 60−2	56
30	7334	60+2, 65−4	62
Aug. 19	7354	51+3, 60−4	55
23	7358	51+3, 60−4	55

* Not seen together.

TABLE XXII.—*Baxendell's Observations of R Scuti*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1851	239+		
Aug. 25	7360	51+1, 60−6	53
Sept. 2	7368	51−2, 60−6	52
21	7387	51+2, 60−6, hazy	54
Nov. 11	7438	51+2, 60−6, very hazy	54
1852			
May 19	7628	<51, 60−6	54
July 27	7697	60−1	59
Aug. 3	7704	60+1, 65−3	62
13	7714	60−2	58
Sept. 1	7733	51+5, 60−6	55
16	7748	<51, 60−6	54
1853			
May 31	8005	51+5, 60−4	56
June 6	8011	51+3, 60−5	54
19	8024	= or >51	?51
July 7	8042	51+5, 60−4	56
22	8057	51+5, 60−4	56
28	8063	51+2, 60−10	52
Aug. 2	8068	51+2, 60−6	54
28	8094	51+5, 60−2	57
Sept. 5	8102	60−1	59
1854			
July 23	8423	51+2, 60−10	52
Aug. 28	8459	51+5, 60−3	56
Sept. 10	8472	Between 65 & 69	?67
13	8475	65+3, 69−3	67
Oct. 15	8507	<51, 60−6	54
Nov. 8	8531	<51	?
1855			
June 23	8758	= or >51, 60−6	?52
Aug. 1	8797	<51, 60−6	54
24	8820	=or>51, 60−12	?49
30	8826	51+0, 60−60	50
Sept. 5	8832	=or<51, 60−10	?51
1855	239+		
Sept. 6	8833	51+2, 60−6	54
24	8851	=or<51, 60−10	?51
Oct. 5	8862	<51, 60−6	54
7	8864	<51, 60−10	?51
14	8871	51+3, 60−6	54
18	8875	51+3, 60−6	54
		$51+\frac{1}{4}(60-51)$	53
21	8878	$51+\frac{1}{4}(60-51)$	53
27	8884	$51+\frac{2}{5}(60-51)$	55
31	8888	$51+\frac{2}{5}(60-51)$	57
Nov. 1	8889	$51+\frac{3}{5}(60-51)$	57
2	8890	$51+\frac{3}{4}(60-51)$	58
3	8891	$51+\frac{9}{11}(60-51)$, 60−4	57
1856			
May 10	9080	69+5	74
29	9099	Between 65 & 69	?67
June 3	9104	= or <65, >69	?66 or 65
4	9105	61+2, >65	63
9	9110	51+3, 60−6	54
15	9116	51+2, 60−10	52
20	9121	>51	
28	9129	51−1 (naked eye, 51+1)	?51
30	9131	51+1	52
July 8	9139	51+3, 60−10	52
12	9143	51+4	55*
22	9153	51+3, 60−6	54
28	9159	$51+\frac{3}{4}(60-51)$	?58
30	9161	60−4	?56†
Aug. 1	9163	$51+\frac{4}{5}(60-51)$	58
2	9164	60−4	56
3	9165	$51+\frac{11}{15}(60-51)$	59
4	9166	$51+\frac{13}{15}(60-51)$	59
6	9168	$51+\frac{13}{15}(60-51)$	59
8	9170	$51+\frac{13}{15}(60-51)$	59

* Var. is a min. vis. to naked eye.

† "Less bright than on 28th."

TABLE XXII.—*Baxendell's Observations of R Scuti*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1856	239+		
Aug. 19	9181	$51+\frac{1}{2}(60-51)$	52
22	9184	$51+\frac{1}{3}(60-51)$	54
28	9190	$51+\frac{2}{5}(60-51)$	55
29	9191	$51+\frac{1}{3}(60-51)$	54
Sept. 4	9197	$\frac{1}{2}(60+51)$ or brighter	?55
5	9198	$51+\frac{2}{7}(60-51)$	55
7	9200	$\frac{1}{2}(60+51)$	56
29	9222	$51+\frac{3}{8}(60-51)$, $60-6$	55
Oct. 1	9224	$51+5, 60-6$	55
5	9228	$51+\frac{2}{7}(60-51)$	54
17	9240	$51+\frac{2}{15}(60-51)$, $51+2$	53
19	9242	$51+\frac{2}{15}(60-51)$, $51+2$	53
Nov. 11	9265	$51+2, 60-6$	54
,,	,,	$51+\frac{2}{5}(60-51)$, $60-10$	52
27	9281	$51+11, 60-2$	60
1857			
May 8	9443	$51-1, 60-7$	52
15	9450	$51-2$	49
19	9454	$51-1$	50
21	9456	$51+1$	52
24	9459	$51+2, 60-11$	51
26	9461	$51+2, 60-9$	52
30	9465	$51+3, 60-7$	54
June 4	9470	$51+3, 60-6$	54
14	9480	$51+5, 60-1$	58
15	9481	$51+5, 60+0$	58
17	9483	$60+1$	61
19	2485	$60+\frac{1}{2}, 65-\frac{1}{2}$	62
21	9487	$\frac{1}{2}(60+65)$	62
24	9490	$\frac{1}{2}(60+65)$	62
25	9491	$\frac{1}{2}(60+65)$	62
26	9492	$\frac{1}{2}(60+65)$	62
July 1	9497	$60-1$	59
July 11	9507	$51+4, 60-3$	56
12	9508	$51+3, 60-3$	56
16	9512	$51+3, 60-3$	56
19	9515	$51+3, 60-3$	56
25	9521	$51+3, 60-4$	55
Aug. 3	9530	$51+1, 60-8$	52
9	9536	$51+2, 60-5$	54
16	9543	$51+4, 60-3$	56
18	9545	$51+4, 60-3$	56
21	9548	$60-3$	(57)*
24	9551	$51+4, 60-3$	56
27	9554	$51+5, 60-3$	56
28	9555	$60-3$	(57)*
Sept 7	9565	$51+1, 60-6$	53
10	9568	$51+0, 60-7$	52
16	9574	$60-5$	(55)*
17	9575	$51+0, 60-5$	53
19	9577	$51+0, 60-5$	53
20	9578	$51+2, 60-5$	54
23	9581	$51+2, 60-7$	53
Oct. 6	9594	$51+5, 60-4$	56
Nov. 15	9634	$69+2$	71
1858			
Apr. 9	9779	$69+0$	69
May 5	9805	$60+0$	60
31	9831	$51+2, 60-8$	52
June 6	9837	$51+3, 60-7$	54
7	9838	$51+3, 60-7$	54
8	9839	$51+3, 60-7$	54
15	9846	$51+3, 60-7$	54
21	9852	$51+2, 60-8$	52
26	9857	$51+3, 60-8$	53
July 1	9862	$51+2, 60-8$	52
2	9863	$51+2, 60-7$	53
6	9867	$51+1, 60-7$	52
10	9871	$51+0, 60-8$	52
17	9878	$51+2, 60-7$	53
18	9879	$51+2, 60-7$	53

* These apparent irregularities are due to a single comparison being made instead of two.

TABLE XXII.—*Baxendell's Observations of R Scuti*—continued.

Date.	J.D.	Corrected Comparisons.	Deduced Mag.
1858	239+		
July 28	9889	51+3, 60−7	54
Aug. 5	9897	60−6	54
10	9902	51+3, 60−5	54
12	9904	51+4, 60−6	54
Sept. 5	9928	51+5, 60−3	56
Oct. 28	9981	51+2, 60−5	54
Nov. 6	9990	51+1, 60−6	53
1859	240+		
May 2	0167	51+5, 60−3	56
8	0173	51+5, 60−2	57
22	0187	60+1	61
28	0193	60+0	60
29	0194	60−1	59
June 8	0204	60−3, doubtful, clouds	?57
10	0206	51+2, 60−5	54
22	0218	51+0	51
July 9	0235	51+5, 60−4	56
10	0236	51+5, 60−5	56
Sept. 3	0291	51+0, or brighter	?51
1868			
July 10	3524	60−7	53
23	3537	60−6	54
27	3541	60−3	57
1877	240+		
Sept. 12	6875	60−3	57
15	6878	60−5	55
20	6883	60−6	54
21	6884	60−6	54
Oct. 8	6901	60−3	57
29	6922	60−3	57
1878			
Aug. 2	7199	60+6	66
8	7205	60+4, 65−2	64
18	7215	60+1	61
25	7222	60−2	58
Sept. 2	7230	60−4, 51+0 (naked eye)	54
11	7239	60−5, 51+0 (finder)	53
Oct. 17	7275	51+3, 60−3	56
1880			
July 31	7928	60+0	60
1881			
May 20	8221	60−5	55
1884			
Aug. 23	9412	60−5	55
Sept. 20	9440	60+3	63

Consideration of these observations shows that the variation in brightness is irregular, both as to amount and period. But on a careful investigation certain features become evident. The mean magnitude is about 5·4, and there are quite clearly marked maxima and minima which apparently recur at *mean* intervals of about 69½ days, though the actual, individual intervals range from less than 50 to over 100 days. The maxima do not usually differ from 5·0 magnitude by more than 0·2 magnitude either way; but the minima may be divided into "deep" and "shallow" ones, of which the former vary from about 6·7 to 7·6, and the latter from 5·55 to 6·25. About twice as many shallow minima as deep ones are observed, and there are several instances of a deep minimum followed or preceded by two shallow ones, while there is no example of two deep ones in succession. The form of the light curve is often very like that of R Sagittæ, only that in the case of the latter star, deep and shallow minima usually alternate.*

* See *M.N.*, **76**, 659.

The following table gives approximate dates of observed maxima and minima :—

TABLE XXIII.

Maxima and Minima of R Scuti.

Period.	Observed Max.	Interval.	Observed Min.	Interval.	Deep or Shallow.	M − m.	m − M.
1	239+	...	6296± 4	...	D	...	...
5	6523± 6	...	6565± 2	...	S	(42± 8)	(72± 4)
6	6637± 2	114± 8	?6674± 3	(109± 5)	S	...	...
10	...	...	6928± 6	...	S	...	32± 8
11	6960± 2	...	6992± 6	64±12	S	32± 8	35±14
12	7027± 8	67±10	7062± 6	70±12	D	*35±14	...
16	...	...	7340± 6	...	S	...	34±10
17	7374± 4	...	?7408± 8	(68±14)	?	(34±12)	...
21	...	...	7705± 4	...	S	...	...
26	8026± 4	...	8048± 4	...	S	22± 8	(25±14)
27	8073±10	(47±14)	...	...	...	...	...
32	...	...	8476± 8	...	D	...	...
38	8822± 6	...	...	...	?	...	...
41	...	...	9079± 7	...	D	...	*43±10
42	9122± 3	...	9167± 5	88±12	S	45± 8	(13± 7)
43	9180± 2	58± 5	9212± 6	45±11	S	32± 8	38±12
44	9250± 6	70± 8	...	...	...	...	...
47	9450± 2	...	9489± 4	...	S	39± 6	39± 8
48	9528± 4	78± 6	9549± 6	60±10	S	21±10	20± 9
49	9569± 3	41± 7	?9622±16	(73±22)	D	*(53±19)	...
51	...	...	?9780±15	...	D	...	...
57	240+	...	0184± 3	...	S	...	36± 7
58	0220± 4	...	...	...	...	...	...
158	...	...	?	...	D	...	...
159	7245± 9	...	...	...	...	...	...
Mean	...	69½	...	69½	...	34	35

Those in brackets have been given half weight. All the observed intervals from maximum to maximum have shallow minima, but the *'s show *half* periods with deep minima. In addition to the above dates, a bright maximum is indicated on (or near) 2393404, and deep minima within about 20 days of 2393747, 2395577, 2399776, 2407187, and 2409445, respectively. (Probably within 10 days of 2407187.) But the last of all might possibly not be a deep one.

The deep minima during this series occur at intervals of about 11, 20, 9, 8, and 2 multiples of 69½ days, so that it is possible that they recur in every second or third "period," not always alternating between the second and third, though possibly usually doing so.

Thus they might occur in periods **1**, 4, 7, 9, **12**, 14 or 15, 17, 19 or 20, 22, 24 or 25, 27, 29 or 30, **32**, 34, 36, 38 or 39, **41**, 44, 46, **49**, **51**, 54, 56. Those in heavy type are the observed examples, and the others are all possible, and some of them probable. We might put period 35, instead of 34 and 36. The observed shallow minima are in periods 5, 6, 10, 11, 16, 21, 26, 42, 43, 47, 48, 52, and 57.* The two earlier deep minima would be 10 and 37 periods respectively before the first of this series, and the two later ones would be in periods 158 and 190, but the last is doubtful as regards depth. Other alternatives might be suggested, but all must be merely tentative at present, and it seems desirable that this star should be carefully watched.

TABLE XXIV.

Comparison with a Uniform Period of 69·5 *Days.*

(*For "observed" dates, see Table XXIII.*)

Period.	U. (Maximum.)	O−U. (Least.)	U. (Minimum.)	O−U. (Least.)	Mean.	Depth.
	239+					
1	6265	...	6300	0	(0)	D
5	6543	−14	6578	−11	−12	M
6	6613	+22	6648	?+23	+22	S
10	6891	...	6926	0	(0)	M
11	6960	0	6995	0	0	S
12	7030	0	7065	0	0	D
16	7308	...	7343	0	(0)	M
17	7377	0	7412	?0	0	?
21	7655	...	7690	+11	(+11)	M
26	8003	+19	8038	+6	+12½	?M
27	8072	0	8107	...	(0)	?
32	8420	...	8455	+13	(+13)	D
38	8837	−9	8872	...	(−9)	?
41	9045	...	9080	0	(0)	D
42	9115	+4	9150	+12	+8	M
43	9184	−2	9219	−1	−2	S
44	9254	0	9289	...	(0)	?
47	9462	−10	9497	−4	−7	M
48	9532	0	9567	−12	−6	S
49	9601	−29	9636	?0	−15	D
51	...	...	9775	?0	(0)	D
57	9157	...	0192	−5	(−5)	M
58	0227	−3	0262	...	(−3)	?
Mean	...	−1	...	+2	0	

* Of these, 5, 10, 16, 21, ?26, 42, 47, and 57 are less shallow than the others, and are reckoned as "medium" for Tables XXIV. and XXV. Here again a series of twos and threes, generally alternating, would fit the case.

The *usual* alternation seems to be D, M, S (Deep, Medium, Shallow).

No mean light curve can be obtained in the ordinary manner; but there are four well-observed series of about 200 days each, those of 1849, 1850, 1856, and 1857. The first contains the abnormal long period; each of the others consists of a nearly complete set of 3 periods, with 1 deep and 2 shallow minima, and they are very similar in form. From these three sets (with the addition of a fairly well-observed deep minimum in 1848) a smooth curve was obtained for a 207 days' period, analysis giving, when the origin of θ is suitably chosen,

$$0{\cdot}44\cos(\theta-6^\circ)+0{\cdot}49\cos 2(\theta+6^\circ)+0{\cdot}55\cos 3(\theta-2^\circ)+0{\cdot}15\cos 4(\theta-10^\circ),$$

which is very nearly

$$0{\cdot}50(\cos\theta+\cos 2\theta+\cos 3\theta).$$

This curve can readily be drawn, showing the deep minimum and two shallow ones, the ratio of the amplitudes being about as 3·4 to 1. If we add a term $\cos 4\theta$, we get a deep minimum with 3 shallow ones, ratio about 4 to 1, and doubtless the series continues, though it has not been verified further. It seems of interest to call attention to this association of three cosine terms (approximately), since Larmor and Yamaga have recently* pointed out that the sun-spot curve is approximately composed of sine terms only, being thus "antisymmetrical."

Restriction to two terms $\cos\theta+\cos 2\theta$ gives us, of course, one deep and one shallow minimum, as was found for R Sagittæ (*M.N.*, 76, 675), though sometimes the deep minimum comes first (type A), and sometimes the shallow (type C). The resemblance between the R Sagittæ curve and two-thirds of the R Scuti curve (one deep and one shallow minimum) was so striking to the eye as to lead to the following numerical comparison. The figures for R Sagittæ will be found on p. 676 *loc. cit.*, but are rearranged in an obvious manner; the unit is 0·01 magnitude.

R Sagittæ.

A	899	912	911	905	904	916	940	980	975	908	884	888
C	910	916	915	906	906	912	927	966	953	908	898	900
Mean	904	914	913	905	905	914	934	973	964	908	891	894

R Scuti.

	536	560	546	528	528	550	614	736	732	566	500	514

* *Proc. R.S.*, 93, 493.

If now we subtract the constant 907 from the mean curve for R Sagittæ; and if after subtracting 540 from R Scuti we divide the residuals by 3, we get the following figures:—

Sag. $-3+7+6-2-2+7+27+66+57+1-16-13$
Scut. $-1+7+2-4-4+3+25+65+64+9-13-9$

a resemblance so close as to seem significant, though it may be no more than a coincidence.

However, as regards R Scuti, it has been shown already that deep minima do not occur regularly in every third period, but sometimes—certainly in one case, and probably in others—have only one shallow minimum between them, as with R Sagittæ. The above expression $(\cos\theta+\cos 2\theta+\cos 3\theta)$ does not therefore correspond to any permanent feature of the variation. If we fix attention on the shorter period of about 69 days, the separate cycles nevertheless vary so much in length, that the only satisfactory way of superposing them is to read off 12 equidistant points in each. In this way we may obtain three different curves which we may call deep (D), medium (M), and shallow (S); the average lengths of period being for D 84 days, for M 82 days (or less), and for S 58 days. The excesses over 5·00 magnitude in units of 0·01 magnitude are as in Table XXV.

TABLE XXV.

Light Curves of R Scuti: single periods.

D	20	25	60	110	170	215	215	170	110	60	25	15
M	15	25	40	60	85	90	90	80	60	45	30	20
S	20	25	35	45	50	55	50	50	30	30	20	20
Mean	18	25	45	72	102	120	118	100	67	45	25	18

The mean curve when analysed gives (restoring the unit to 1 magnitude)—

$$0\cdot53\cos(\theta-164^\circ)+0\cdot07\cos 2(\theta-163^\circ),$$

which again can be reduced to the form

$$\cos\theta+0\cdot13\cos 2\theta,$$

consisting of two simple cosines though with unequal coefficients. The coefficient of the third harmonic comes out sensibly zero.

The very long period of 1849, being specially well observed, has also been analysed individually; the only gap in the observations (portion 9) being filled in by the eye. The figures are (on same plan as Table XXV.)—

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
15	35	50	80	95	85	80	70	60	40	30	10

The analysis gives, in units of 1 magnitude :—

$$0^{\cdot}39 \cos(\theta - 153^{\circ}) + 0^{\cdot}09 \cos 2(\theta - 93^{\circ}).$$

There is no third wave, just as in the mean curve, and the resemblance is fairly close ; but the range in this period is rather less, and the minimum does not come half way between the maxima, so that the phases of the two waves are not identical as in the other.

Concluding Note to Long-period Variables. By H. H. Turner.

The circumstances under which Baxendell's observations came into my hands are outlined in *M.N.*, **68**, 119 and 316 : see also **71**, 702, and **73**, 124. Those long-period variables which have been at all well observed have now been dealt with, and though there are other observations, it is not proposed to discuss them at present.

Practically the whole of the work of editing has been undertaken by Miss Blagg.* The difficulties of identification have been noted frequently ; they could scarcely have been overcome without her patience and care. I feel that we are specially fortunate also to have had the same devotion in discussing the observations. These early records are precious material, of which it is important to make the most ; and to concentrate full attention on one star at a time, as Miss Blagg has been able to do, probably gives the best chance of getting the full value of the record. It may be that something has been missed by the consequent protraction of the study,—something which might conceivably have emerged from the consideration of several stars together ; but at the outset of this work we were rather in the dark as to any rational grouping of these stars (though Mr. Phillips has found a valuable clue recently). The facts that the whole series was gone through twice over (first in preliminary fashion and then for press), and that Miss Blagg more than once remembered enough of one star to connect it with another (*e.g.* R Sagittæ with R Scuti and S Vulpeculæ), give, however, some ground for hope that nothing essential has been overlooked.

Experience of the "personalities" of other variable star observers led me to attach importance to the discussion of the work of one observer in isolation ; but I carried this principle too far in the case of the earlier Baxendell stars. There is no reason

* Under the constant direction and supervision of Professor Turner, to whose final decision doubtful and difficult points have always been referred.—M. A. B.

why, when the corrections to epoch have been obtained, other determinations should not be brought alongside, as has been done for the later stars. The earlier would probably gain by rediscussion in this way.

Further, at the outset I estimated too highly the probability that there was a regular fluctuation of the period, as represented by Argelander and Chandler. In no case that I know of has the existence of *one simple* such term been confirmed by recurrence in a second fluctuation. In 1915 Mr. Phillips showed that the maxima of S Herculis could be fitted to a fluctuation represented by a combination of several periodic terms, but their ultimate recurrence is still doubtful, and the simpler hypothesis of several changes of period, more or less abrupt, will fit the observations almost equally well (*M.N.*, 75, 563, and 76, 185). Since that time, although simple periodic fluctuations have been calculated for other stars, the "discontinuity" hypothesis has been exhibited as an alternative, and personally I have lost faith in the periodic fluctuations.* On the other hand, there are undoubted changes of period in some cases (*e.g.* S Herculis above mentioned), though other stars seem to vary regularly. It would be hard to say which type of variation it is more important to watch—the steady stars to verify their steadiness, or those which change their period in order to verify the changes and possibly discover their law. Perhaps the observer will be most attracted by the changing periods, as he was originally attracted to variables by their changing light: but some stars of apparently constant light have recently yielded to close scrutiny, showing minute changes; and in the same way the variables of apparently constant period may ultimately disclose small changes in period linking them up with the others; while they in turn may link up with the "irregular" variables. He would be a bold man who should declare that any variable star had been watched so long and closely that it might now be neglected; for even with the law of gravitation to guide us we cannot yet say this of planetary movements, while for variables we have as yet nothing corresponding to Newton's law, or even Kepler's laws. The main outcome of discussion up to the present is the call for more observations of all kinds: excellent response is being made by the British Astronomical Association, but even ten times the work might profitably be done.

The following summary and index to the Baxendell stars may be convenient for reference:—

* I entirely concur in this.—M. A. B.

	Date of Paper.	Reference to *M.N.*	Variation.	Light Curve.	Ref. No. Bax.	Chandl.	Harv.
S Aquilæ	1917 May	77, 563	Discon.	?	24	6726	200715
R Arietis	12 Dec.	78, 124	Uniform	I.	1	782	021024
	14 Mar.	74, 452	,,	,,	,,	,,	,,
R Boötis	14 Mar.	74, 452	Periodic ?	I.	2	5237	143227
U Boötis	18 May	78, 491	Uniform ?	III. ?	25	5338	144918
R Cancri	14 Mar.	74, 459	?	?	3	2946	081112
U Can. Min.	18 May	78, 498	Discon.	I.	26	2735	073508
R Coronæ	14 Mar.	74, 463	Irreg.	...	4	5667	154428
S Coronæ	14 Mar.	74, 474	Periodic ?	II.	5	5504	151731
U Cygni	14 May	74, 568	Uniform	I.	6	7299	201647
χ Cygni	18 May	78, 507	Uniform ?	?	27	7120	194632
R Delphini	14 May	74, 575	?	II. ?	7	7261	201008
S Delphini	14 May	74, 579	Periodic ?	?	8	7431	203816
T Delphini	14 May	74, 593	Uniform	?	9	7444	204016
S Gemin.	15 Mar.	75, 398	Uniform	?	10	2742	073723
U Gemin.	07 Mar.	67, 316	Irreg.	...	...	2815	074922
R Herculis	15 Mar.	75, 405	Periodic ?	?	11	5770	160118
S Herculis	15 Mar.	75, 411	Periodic ?	I.	12	6044	164715
	T.E.R.P.	75, 563	Periodic ?	,,	,,	,,	,,
	15 Dec.	76, 185	Discon.	,,	,,	,,	,,
T Herculis	15 Dec.	76, 158	Periodic ?	I.	13	6512	180531
	16 Apr.	76, 469	Discon. ?	,,	,,	,,	,,
	16 Apr.	76, 492	Uniform	,,	,,	,,	,,
	17 May	77, 577	Discon. ?	,,	,,	,,	,,
U Herculis	18 May	78, 520	Discon.	II.	28	5889	162119
R Leonis	15 Dec.	76, 169	Discon.	I.	14	3493	094211
S Orionis	15 Dec.	76, 186	Uniform ?	I.	15	1944	052404
α Orionis	11 June	71, 701	Irreg.	...	...	2098	054907
R Persei	16 Apr.	76, 483	Discon.	II.	16	1222	032335
	,,	76, 493	,,	,,	,,	,,	,,
R Sagittæ	16 June	76, 659	Irreg. ?	...	17	7257	200916
R Scuti	18 May	78, 527	Irreg.	...	29	6733	184205
R Serpentis	16 June	76, 683	Discon.	?	18	5677	154615
	17 May	77, 578	,,	,,	,,	,,	,,
T Serpentis	16 June	76, 690	Uniform ?	?	19	6624	182306
T Tauri	16 Dec.	77, 125	Irreg.	...	20	1537	041619
R Urs. Maj.	16 Dec.	77, 128	Uniform	?	21	3825	103769
,, ,,	Pogson	76, 480	,,	,,	,,	,,	,,
S Urs. Maj.	16 Dec.	77, 133	Discon.	I.	22	4557	123961
S Vulpec.	17 May	77, 555	Irreg.	...	23	7106	194427

The star's name in the first column is that now adopted, which in some cases has been changed since Baxendell began his observations. Thus he called χ Cygni at first the "variable in Swan's neck," and afterwards var. χ or χ, there being an "old χ" which he had wrongly identified.* R Delphini he called S Aquilæ throughout, so that S and T Delphini were denoted R and S by him. Finally, S Vulpeculæ was denoted S (2) Vulpec. by Baxendell.

The second and third columns give references to the star in the present series of papers. The dates are given in view of the progressive changes in treatment above noted.

In the fourth column "Uniform" means merely that the observations studied give no sufficient evidence of a change of period, not that they are necessarily inconsistent with changes. Similarly "Periodic" means that a simple Argelander-Chandler term can be given which satisfies the observations studied: it does not mean that the fluctuation has yet been confirmed by repetition, for, as above stated, no such case is yet known to me. Cases where there is good evidence of change of period are generally marked "Discon.," though some of them, especially those discussed early, may come under the head "Periodic." The term "Irreg." explains itself.

The fifth column gives Phillips' classification into Group I. or Group II. Cases where no light curve was determined even though the variation is fairly regular, are queried. The "III.?" for U Boötis is explained in the paper. For the classification, see the Presidential Address by the Rev. T. E. R. Phillips to the British Astronomical Association (*B.A.A. Journ.*, 27, 7). See also *M.N.*, 78, 92, 161, and 185.

The sixth column contains the reference number used in these papers, and is of no permanent importance.

The seventh column gives Chandler's reference number, used in his Catalogues and in Hagen's Atlas Stell. Var.

The eighth column gives the Harvard number, which also gives the approximate place for 1900, the first four figures giving hours and minutes of R.A., the last two the degrees of declination.

Among miscellaneous matters dealt with may be mentioned:—

The early notation of WH, for which see *M.N.*, 71, 702, 76, 171. See also *Phil. Trans.*, 205 A, 400.

The full discussion of α Orionis by Professor Plummer, with the negative conclusions that no seasonal variation could be detected, nor any regular period of variation, particularly the suggested period of six years. (See the paper quoted.)

The similarity of R Scuti and R Sagittæ and, in a lesser degree, S Vulpeculæ.

The peculiar light curve of R Scuti, represented by cosine terms only.

* These two stars are called χ^1 and χ^2 in at least two modern star atlases.